ARTIFICIAL SUNLIGHT AND ITS THERAPEUTIC USES

HUMPHRIS

SECOND EDITION

OXFORD MEDICAL PUBLICATIONS

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FRANCIS HOWARD HUMPHRIS

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BY THE SAME AUTHOR

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FOR
PRACTITIONERS
SECOND EDITION, 1921

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AND
ITS THERAPEUTIC USES

BY
FRANCIS HOWARD HUMPHRIS
M.D. (Brux.), F.R.C.P. (Edin.), M.R.C.S. (Eng.), L.R.C.P. (Lond.)
L.M. (Rot., Dublin), D.M.R. & E. (Cantab.)
HON. CONSULTING X-RAY PHYSICIAN TO THE AMERICAN HOSPITAL IN LONDON
HON. CONSULTING X-RAY PHYSICIAN AND ELECTROTHERAPIST TO CHRIST'S HOSPITAL
HON. CONSULTING PHYSICIAN TO THE GUILDHALL SCHOOL OF MUSIC
LATE OFFICER IN CHARGE X-RAY AND ELECTROTHERAPEUTIC DEPARTMENTS 3RD LONDON GENERAL HOSPITAL; CAPT. R.A.M.C. (T.F.)
LATE CONSULTING X-RAY PHYSICIAN TO THE FORCE IN EGYPT; MAJOR R.A.M.C.
PAST PRESIDENT OF THE AMERICAN ELECTROTHERAPEUTIC ASSOCIATION
PRESIDENT OF THE HUNTERIAN SOCIETY
PRESIDENT OF THE BRUSSELS MEDICAL GRADUATES' ASSOCIATION
PAST VICE-PRESIDENT OF THE SECTION OF ELECTROTHERAPEUTICS ROYAL SOCIETY OF MEDICINE
FELLOW OF THE BRITISH INSTITUTE OF RADIOLOGY
MEMBER OF THE RONTGEN SOCIETY

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DEDICATED

TO

MY FATHER

(ON HIS 88TH BIRTHDAY)

WHOSE AFFECTIONATE ENCOURAGEMENT

HAS ALWAYS STIMULATED ME TO FRESH ENDEAVOURS

PREFACE TO SECOND EDITION

OWING to *Artificial Sunlight* being exhausted within six months of its publication, it has been necessary to prepare a Second Edition.

I have endeavoured to make it more than a reprint. Several errors which were made in the First Edition have been corrected, for this my thanks are due to my friends Major Turrell, Major J. Curtis Webb, Dr. W. G. Harvey, and others, and several chapters have been slightly enlarged. I have also made the bibliography more complete, so as to comprise a list of those works to which I am indebted, and to which reference has been made in the text, in order that any reader who wishes for fuller information may be able to seek it at its source.

More illustrations have been added in the description of the general body-bath, and the technique of this treatment discussed in detail. The importance of this branch of ultra-violet therapy becomes more evident even day by day.

I have been careful to refrain from that form of hyper-enthusiasm which creates a reaction of doubt, but the remembrance of patients who have benefited from this form of treatment makes this a task of some difficulty.

I have mentioned certain diseases or conditions in which the pathology suggests that treatment by ultra-violet radiation would be indicated. And though I have not as yet used it in these cases, I have shown why it would probably be successful. In this category I have suggested ultra-violet radiation in the prophylaxis of rickets, the sterilisation of the bladder contents in cystitis, the treatment of sprue, the relief of sterility, and in the attempt to render ready for operation those who suffer from a deficient blood coagulation.

An endeavour has been made in this edition to explain the extreme simplicity of the sources and working of ultra-violet radiation, to elucidate the apparent mystery of its nature, and to explain the details of the treatment so that any ordinary intelligent medical man shall be able to instal an equipment and treat the patients with no further instruction than is contained in these pages, and so be able to take advantage of the enormous assistance which Artificial Sunlight is able to render in the daily round and common task of medical life.

F. H. H.

MAYFAIR, LONDON, W. 1,
May 1925.

PREFACE TO FIRST EDITION

THIS is not an elaborate treatise on the therapy of artificial sunlight, nor is it an exhaustive account of what has been done in this direction. What it is, is merely an attempt to put in handy form and simple language the main conclusions that have been arrived at, experimentally and clinically, by authoritative research workers. Incidentally I embody some of the more important results which ultra-violet radiation has attained in my own practice.

In writing this volume, I am actuated by two leading considerations. The first is to be of service to those practitioners of medicine who have already had their attention aroused to the possibilities of this still little known region of physical therapeutics; and the second is to awaken and stimulate the attention of those who have not given the matter the care and thought it merits.

" Light is, as we know, of universal necessity to the life and well-being of cell-development and sustenance. Without it, proper metabolism is impossible; and when scientifically applied in suitably selected cases it will do more than any other one thing to restore normal physiological conditions." This I wrote in 1911,[1] and since then, though more sure than ever of the truth of my statement, I have encountered a good deal of difficulty in the study of the subject.

---

[1] *Archives of the Röntgen Ray*, October 1911.

One initial difficulty that always confronts the medical man who is making researches into the therapeutic effects of a new agent such as artificial sunlight, is that much of the existing literature on the subject is confused and formless.

Actinotherapy is in a state of evolution. New sources of artificial sunlight are being invented and old ones improved. New uses for this form of therapy are being found every day. The field of its application is being widened and broadened, until one is amazed at the possibilities before it, and to-day I feel that its adoption by the profession at large is not in the dim and distant future, but that now is the appointed time.

To adopt a new technique in medicine is always a daring step. Still, if such a step be not taken, progress in the healing art is impossible. After all, every technique evolved in the laboratory and in the clinic, even those which now have the dust of ages upon them, began by being new, and the application thereof was often empirical. Yet empiricism is not necessarily bad. Indeed, it may be contended that every therapeutic measure now practised for the alleviation of human suffering and the cure of disease originated in empiricism.

Reading a text-book (or, for that matter, a library of text-books) will not do everything. There is always the personal equation. To

secure beneficial results from the practice of ultra-violet radiation in any of its various forms, it is imperative to bring qualities of common sense, watchfulness and deduction, to bear upon each case offered for treatment, and to treat the patient and not the disease.

Moreover, with these the practitioner must have a basis of some sort of general knowledge of actinotherapy; its nature, the necessary instruments, its effects, and the pathological conditions in which it is indicated. It is to supply in a compact form these essentials that these chapters have been written, and their purpose is to serve as a general introduction to treatment by artificial sunlight.

I am not claiming for artificial sunlight that it is a panacea for all the ills to which the flesh is heir. It is only one more weapon in the armamentarium of the fully equipped physician. I think that properly selected cases treated with correct technique, will have their time of treatment shortened by ultra-violet radiation, and that this therapy will help to cure obstinate cases, which might otherwise continue without relief.

The curtain is even now going up on the prospect of the possibilities of actinotherapy. These are well-nigh boundless, and one has but to peer into their potentialities to feel enthusiasm rising within one, and to carry oneself forward among the workers in it.

I must apologise for the number of quotations, but in a therapy so highly specialised as ultra-violet radiation, and in one in its present form so recent, personal experience is necessarily limited, and I acknowledge with gratitude the information I owe to such distinguished authorities as Professor Sir W. M. Bayliss, Sir Henry Gauvain, Doctors Leonard Hill, M. Luckiesh, A. J. Pacini, A. Rollier, C. W. Saleeby, C. M. Sampson, and W. J. Turrell, among the moderns, and to many others to whose works I have referred in my text.

F. H. H.

LONDON, *6th September* 1924.

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ULTRA-VIOLET RAYS HISTORICALLY CONSIDERED

CHAPTER I

ULTRA-VIOLET RAYS HISTORICALLY CONSIDERED

It has been laid down on quite incontrovertible authority, that "there is nothing new under the sun." Hence it may safely be taken for granted that the therapy of ultra-violet radiation, in some form or another, is of very considerable antiquity. To trace the history, however, of the ultra-violet rays as now employed therapeutically, would require the filling of many bulky volumes. Only a mere sketch of the subject can be compressed within the limits of a single chapter.

"Light is the life of man," was written centuries ago, and people will be writing the same thing in centuries to come. Light is a paramount necessity to the well-being and very existence, to the development and sustenance, of human beings. Without light, proper metabolism is impossible, and when scientifically applied to suitably selected cases, it will do infinitely more than any other agent in the service of man to restore normal physiological conditions.

This much by way of preliminary.

Researches show that light, in the form of the rays of the sun, was employed therapeutically from the earliest era of which any record exists. In fact, it would not be too much to claim, that the destiny of the animate world in which we live has been largely directed and governed by the sun; and the trained observation of keen intelligences has, from the birth-pangs of time itself, made a close, if not always very successful, study of the utilitarian properties of controlled light. Writing in 350 B.C., Aristotle noted the effect of daylight in producing green colouring in vegetable matter, and the early dyers and bleachers learned many valuable lessons from Nature's text-book.

Long after Aristotle, the French savant, Jean Ingen-Housz (1780), elaborated his theory by declaring that "sunlight alone can produce in the leaves that movement which can develop dephlogistical air"; and Marshall Ward (1892) noted the death-dealing effect of light on certain bacteria. He did not, however, observe that this was due to the ultra-violet rays. In 1877, a paper was read on the lethal action of the ultra-violet rays on bacteria, and showing how they would destroy the hay bacillus, the bacillus of putrefying hay. It was published in the *Proceedings of the Royal Society* for December of that year, and was contributed by A. Downes and T. P. Blunt. Ten years later it was pointed out by Hertz, that, when ultra-violet light falls upon a spark-gap, the discharge takes place more readily across it.

It is a matter of common knowledge that the ancient Egyptians, the Greeks, and the Romans were all firm believers in the health-giving efficacy of the sun's rays. Their medical men prescribed them as a matter of course to patients, both for the cure and prevention of all the various diseases and ills that afflict humanity. Herodotus has left it on record that light was to be regarded by the physician who knew his business, as a prefatory means of repelling illness and as a subsequent aid to recovery; and Cicero and the Younger Pliny (A.D. 40–50) tell us that *solaria* were established in the villas of Rome's leading citizens; while Hippocrates, Celsus, and Galen were all strong advocates of heliotherapy.

Apropos the views of Cicero and Pliny, it must be admitted that the people who seem instituted for the purpose of exploding comforting and cherished theories, deny that the *solarium* of the old time Roman villa was a sun-bath. Their view is, that such an adjunct was not used until after night had fallen. But this is by the way.

Notwithstanding the gratifying measure of success that met the early experiments of the workers in this particular field, long centuries elapsed before systematic efforts were made to use light for therapeutic purposes on a really large scale. Such efforts are distinctly modern. In fact, they did not really begin until Professor Finsen had in 1893 published the results of his application of remedial sunlight to the treatment of certain tuberculous disorders.

Apart from its considerable therapeutic triumphs, Finsen's work was crowned by much material reward. Shortly before his premature death he received the Nobel prize for Medicine. What, however, the talented young doctor from Copenhagen valued far more, was the interest shown in him by his countrywoman Queen Alexandra, the result of which was that the London Hospital acquired an installation for the Finsen treatment.

More recently, Peter Cooper Hewitt (who used thallium and cæsium in the construction of quartz mercury arcs in order to increase the output of ultra-violet radiation) lit upon a discovery of the first importance. This was that the ultra-violet rays could be produced by the mercury vapour arc, and were capable of passing through a quartz lamp. The natural result was to give a tremendous impetus to ultra-violet therapy, and, more than anything else, to bring this into general use.

It is not too much to claim, that the first pathway leading to the discovery of invisible radiation, as we now know it, was opened by Isaac Newton. Ultra-violet radiation was actually discovered a little more than one hundred and twenty years ago. During the interval that has since elapsed the workers have not stood still, but have devoted considerable and patient attention to the potentialities of this form of energy. Thanks to the long and careful researches of modern authorities, who have charted the route in the laboratory and

the clinic, these potentialities have now been gradually extended. Thus, not only does invisible radiation assist the physician in his practice and in the consulting-room, but, as its properties, methods of production, and application are better understood, the chemist, the dermatologist, the biologist and the physicist and others all reap the benefit in the common weal.

It was Newton's epoch-making discovery of the spectrum that revealed an unexplored and almost virgin territory, in the field of radiant energy and the composition of light. His long series of patient and tireless researches was finally crowned with splendid achievement; and resulted in the discovery of the variation of refrangibility, with the wave lengths of the radiant energy or radiation. Newton, however, realised only the visible radiation. With the more delicate apparatus now available it would be possible to distinguish upwards of one hundred separate colours in the visible spectrum. He was unaware of the existence of a vast series of radiations, differing in respect of wave lengths and frequency of vibration; only a small part of which is visible light. Great scientist though he was, Newton none the less was hampered by certain disabilities. The simple apparatus of his era kept from him the knowledge, possessed by those who have come after him, that ultra-violet radiation was impinging upon the screen beyond the violet edge of the coloured patch that he projected.

Newton served as a bright torch for the latter half of the seventeenth century, and undoubtedly contributed much to illumine the dark places in the understanding of Romer and Huygens, who flourished contemporaneously with him. In 1777 Scheele took a step forward, when he projected the visible spectrum upon silver chloride, and noted the production of metallic silver in the region of the violet rays. It was only by a very narrow margin that he did not discover the ultra-violet region himself. As a matter of historical fact he left the discovery to Ritter, by whom it was made in 1801, while in 1800 our own Herschel (who had conceived the eminently sound idea of repeating Newton's early experiments) announced to a waiting world the infra-red region. A few years later witnessed the noting by Thenard, Gay-Lussac, and Planche of the various effects of light on hydrogen and chlorine; and it was Grotthus who enunciated the photo-chemical absorption law, that "only the rays absorbed are effective in producing chemical change."

The "Grotthus Law" enunciated more than one hundred years ago by Theodor von Grotthus, was subsequently elaborated by Draper. For this reason it is often known as "Draper's Law." What this amounts to is, briefly, that certain hues are decolorised by others, each being attacked by the light of the colour complementary to its own.

During the early years of the last century, many valuable discoveries in the field of photo-chemical effects crowned the researches of Daguerre, Becquerel, and others.

It was in 1895 that a knowledge of the X-rays was first given to the world by Röntgen. Subsequently these were held to be radiations of short wave lengths, and the gap between them and the shortest known ultra-violet radiation was for the time being unbridged. Since then, however, as will be seen later, this gap has become not only materially decreased, but has vanished altogether.

A man who did something (in fact a good deal) of value for actinotherapy, did not, oddly enough, happen to be a medical man at all. This was Arnold Rickli, who, more than seventy years ago, was sufficiently courageous to strike out a line for himself, and to establish a clinic at Veldes, in Austria, where he installed a sun-bath in conjunction with what he termed the *cure atmosphérique*. This was empiricism, perhaps, but none the less was it justified by its results. At any rate (much to their surprise, no doubt, as well as to that of the faculty), his patients lived. What was still more to the point, they were cured.

In 1903 Dr. Rollier opened at Leysin (French Switzerland) the first clinic in Europe for the systematised heliotherapy of surgical tuberculosis. Seven years later, he started the well-known *école au soleil* at Cergnat, where he has met with a gratifying measure of success in the treatment of maladjustments of metabolism. A contributory factor to this result is to be found in the specially favourable ultra-violet content of the sunlight in the district.

Dr. Rollier's method of treatment begins by exposing the patient's body to the rays of the sun for periods of from five to ten minutes. As the skin becomes pigmented, the sittings are prolonged.

Nearer home, Sir Henry Gauvain, one of the leading practitioners in England of Rollier's method, has used artificial light on a considerable scale during the winter months at Alton, as well as at Hayling Island.

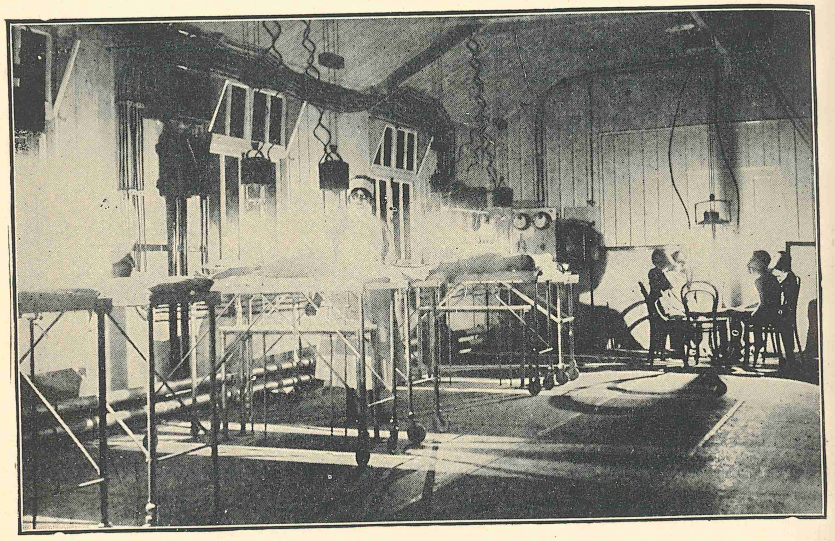


FIG. I.—A CORNER OF THE LIGHT DEPARTMENT AT ALTON.

The Alton installation includes a number of powerful arc lamps; several of 20 ampères for individual treatment, and one of 75 ampères for treating a group of patients.

There is also a Finsen-Reyn lamp, with carbon electrodes. In this lamp the light is transmitted through distilled water, in order to eliminate the heat rays, and project light, that is rich in ultra-violet rays, through water-cooled quartz compressors on to local wounds or lesions. In fact, at Alton all types of lamps are to be found for administering rays of different wave lengths. Among these are water-cooled iron arc lamps, tungsten arc lamps, mercury vapour, aluminium and silicon arcs, together with cadmium and other lamps, each of which serves a specific purpose. In short, the system of Alton approaches perfection, in that it permits the use of radiant energy of different wave lengths (either separately or in combination) for local or general treatment, and for varieties of stages and conditions of the same disease.

A passage from the work of Luckiesh[1] has some bearing on the historical aspect of ultra-violet radiation:

"Until the advent of the electric dynamo the only adequate source of ultra-violet radiation was the sun. This is unsteady, uncertain, and discontinuous as a source, and limited in spectral range in the ultra-violet region. The carbon arc was the first artificial source of appreciable powerfulness, but in the early years of electrical age, the production of ultra-violet radiation in this matter was costly. As the sciences of electricity and of light production advanced, richer and more powerful sources of ultra-violet radiation appeared. However, it may be said that the twentieth century was the first to see the advance of artificial sources of this energy, sufficiently efficient and adequate to draw marked attention to applications on a commercial scale."

---

[1] *Ultra-Violet Radiation*, by M. Luckiesh (D. Van Nostrand Company, New York, 1922).

The continued march of progress in the dual fields of electricity and light, has thus brought into existence fresh sources of ultra-violet radiation. Its really wide application, however, has only just begun to dawn.

Workers in the widely extending fields of ultra-violet radiation are not standing still, and history is yet being written. Less than a year ago London had its first own sun-bath establishment, and facilities for treatment were commenced at Ken Woods, adjoining Hampstead Heath. The organisation responsible for the experiment—the first of its sort to be established in the London district—is under the auspices of the happily named " Sunlight League," and among the distinguished medical men connected with it are Sir William Simpson, Dr. Leonard Hill, of the National Institute of Medical Research, Dr. Hector Munro, and Dr. C. W. Saleeby.

Dr. Pacini, of the department of Biophysical Research of the Victor X-ray Corporation of Chicago, has done well to observe, that ultra-violet therapy has now reached an era of quantitative investigation. As our knowledge of the physical qualities of this energy increases, and its biological action becomes better understood, so will much of the empiricism, that has hitherto hindered its scientific development, be dissipated. The sure and certain result of this is that " there must emerge a science useful in the knowledge of medicine as an implement in the eternal vigilance and use against human disease."

There are still many chapters in the history of ultra-violet radiation waiting to be written. The honour of writing them is within the province of all practitioners of the healing art. The task is no simple one. There will be rebuffs, and there will be disappointments. But there will be also splendid triumphs, and " exceeding great rewards."

ULTRA-VIOLET RAYS—FACTS AND FALLACIES

CHAPTER II

ULTRA-VIOLET RAYS—FACTS AND FALLACIES

As has been seen, practically since the dawn of time, actinic rays from the sun itself have been used in the treatment of disease. The recognition of their value when produced artificially (and in a more concentrated form than that obtained naturally) is, however, of comparatively recent growth. And this, aided by the progress of other branches of electrical and scientific knowledge, has advanced step by step.

Therapeutically considered, it matters very little what light is, and what ultra-violet rays are. Still, a definition is always worth having, and the best one of light up to the present, is that of Sir Oliver Lodge, namely, " Light is an electro-magnetic disturbance of the ether." As for the ultra-violet ray which we are now considering, it may conveniently be defined as an invisible ray whose luminous frequencies are greater than those of the visible spectrum ; and it is called ultra-violet, because it lies just beyond the violet of the visible spectrum. As a ray, it is, like the X-ray, in itself invisible. At this juncture, it may be observed that an initial difficulty confronting the student is, that many authoritative writers on ultra-violet radiation have a confusing practice of allotting different names to the various wave-length sections. Thus, some call the three divisions: (1) Near ultra-violet, (2) far ultra-violet, and (3) extreme ultra-violet; while others adopt the terminology of (1) ultra-violet, (2) ultra-ultra-violet, and (3) Schumann's band or Lyman's band.

Yet they correspond.

The position of the ultra-violet ray may be seen in the accompanying diagram of the spectrum.

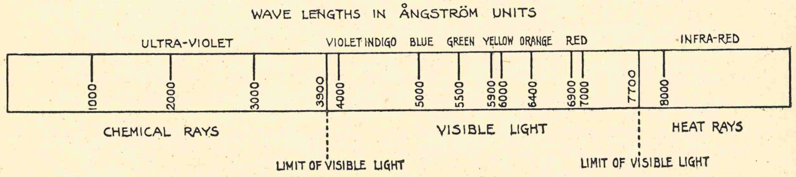


FIG. 2.—DIAGRAM OF THE SPECTRUM.

The ultra-violet ray is known also as the Actinic ray, and is so called by reason of its power to excite chemical action, and because the effect it produces upon photo-sensitive paper is more pronounced than any of the other light rays.

As a definite standard is necessary for purposes of comparison, a unit of measurement has been adopted. It is purely arbitrary and is used as a basis for calculating visible and invisible light wave lengths. This is what is known as the Ångström Unit, and may be defined as a unit of wave-length measurement, whose length is one ten-millionth of a millimetre. Two other units

that also are adopted in ordinary terminology, are the millimicron and the micron.

In this connection it is worth noting that the terms millimicron and micron are convertible terms with the Ångström unit. To change from one to the other is quite a simple matter. All that is necessary in converting millimicrons to Ångström units is to multiply by 10, and in converting Ångström units into millimicrons to divide by 10. Thus a wave length measuring 400 millimicrons would equal 4000 Å, and 4500 Å would equal 450 millimicrons.

The wave length must not be confused with the term frequency, or velocity. Their relative significance may be appreciated from the fact, as laid down by Luckiesh, that the velocity at which radiant energy is transmitted through a vacuum, is independent of the frequency for wave length and is approximately 186,300 miles per second. The frequency is calculated by dividing the known velocity by the wave length; thus the shorter the wave length, the more rapid is its vibratory frequency.

Tabulated, the three terms employed for designating wave lengths are as follows:

UNIT.	SYMBOL.	MILLIMETRES.
Ångström . . .	Å	One ten-millionth.
Millimicron . .	$m\mu$ or $\mu\mu$	One millionth.
Micron . . .	μ	One thousandth.

Of these different terms the Ångström unit is the one most commonly employed.

The ultra-violet field extends from 360 Ångström units (Å) to 4000 Å. It is sometimes divided up as follows: The extreme ultra-violet field extends from about 360 Å down to approximately 2000 Å; the far ultra-violet extends from 2000 Å to 3000 Å; and the near ultra-violet from 3000 Å to 4000 Å.

Before leaving the subject of wave lengths it may help to assist in their comprehension to glance at the approximate wave-length limits of the various spectral regions of radiant energy. In the order of increasing wave length, they are stated by Luckiesh to be as follows:

	Wave Length.
Ultra-violet radiation	0–390 mμ
Extreme region	0–200 „
Gamma rays (arbitrary limits) 0 to 0·01 mμ.	
Röntgen rays (arbitrary limits) 0·01 to 50 mμ.	
Middle or intermediate region . .	200–300 mμ
Near region	300–390 „
Visible radiation	390–770 mμ
Violet	390–430 „
Blue	430–470 „
Blue-green	470–500 „
Green	500–530 „
Yellow-green	530–560 „
Yellow	560–590 „
Orange	590–620 „
Red	620–770 „
Infra-red radiation	0·77–∞ μ
Near region	0·77–20
Infra-red photography to 1 μ.	
Fluorite prism to 10 μ.	
Rock-salt prism to 20 μ.	
Intermediate region	20–500
Selective reflection from rock salt to 50 μ.	
Selective reflection from potassium chloride to 61 μ.	
"Restrallen" method up to 354 μ.	
Electric oscillator method up to 500 μ.	
Extreme region	500–∞
Electric waves such as that radiant energy studied by Hertz, that used in wireless circuits, that resulting from high frequency currents, and that due to ordinary alternating currents, complete a long range of wave lengths to beyond 12 km. in wave length.	

Many years ago I pointed out, and I think it well to do so again, that the explanation of the curative power of sunlight, or of concentrated artificial light, is not yet thoroughly understood. Certain effects such as the dilatation of the cutaneous vessels and the stimulation of the sweat glands are obvious. The deeper action may be due partly to this (for with the filling of the capillaries a depletion of other vessels must follow), and partly to the resistance to the light energy. It is well known that whenever energy meets resistance at any point, heat is generated at that point, *e.g.* the heat generated by a bradawl or gimlet boring into a plank.

Now although the skin is a poor conductor of heat it readily transmits light. In the tissues this light meets resistance, or else it would be transmitted through the whole body. It is at the various points of absorption, that the light rays are transformed into heat energy.

This was written more particularly with regard to high candle-power incandescent light. It may be that in ultra-violet light the rays are transformed into chemical energy, as will be seen later.

The field for inquiry into the exact manner in which the ultra-violet rays exert their beneficent action is by no means exhausted. That, however, their therapeutic value is fully established, is beyond question. The first hundred cases under my own care in 1916–17 which were treated with ultra-violet radiation, were old wounds, trench feet, ulcers in various parts of the body, and inflammation of the cutaneous tissue, the majority of which presented difficulty in healing.

Two of the later chapters are devoted to the particular diseases in which this therapeutic agent is of service, and directions are given for its uses. But, speaking generally, and apart from its universal use in dermatology, it increases the resistance of the body and so enables it successfully to combat specific infections.

An increasingly gratifying measure of success has attended the application of ultra-violet light in the treatment of various tuberculous diseases, more especially in cases of tubercular bone disease and lupus and other skin disorders. It has been found to have a good effect in eczema and rickets, and also in cases in which it is necessary to stimulate the activity of the skin, for the purpose of relieving congestion in the internal organs.

The biological effects of the ultra-violet light are strongly pronounced. When the human skin is exposed to light containing a sufficiency of ultra-violet rays, it gradually becomes red or brown. This is the familiar " sun burn " resulting from a seaside holiday in summer, or from a visit to a winter sports centre in the high altitudes of Switzerland. The pigmentation thus caused is the result of melanin granules forming round the nuclei of the epidermis and the basal cells. At lower altitudes the melanin deposit dissolves, and the " sunburn " disappears.

Pigmentation of the human skin is Nature's automatic defence against absorbing too large a quantity of sunlight. If, however, there has been prolonged exposure prior to the formation of the protecting pigmentation, a degree of inflammation may ensue. In such cases the skin burns and peels, and sometimes there are bad blisters. These are purely superficial, and heal readily without forming any scars. In some cases it may be necessary for the treatment to be pushed to blister formation, as in the treatment of some forms of nævi.

It must be remembered in applying it, that ultra-violet radiation undergoes marked absorption by reflection. Thus snow has been found to be an excellent reflector of the ultra-violet radiation. The reflector factor, indeed, of snow for visible radiation is between 80 per cent. and 90 per cent. Therefore when using the ultra-violet light therapeutically, various substances —sheet tin, white or ivory-tinted enamel, white sheets, and so forth—may be placed so as to reflect the rays to the patient.

Another factor must be borne in mind, and that is the angle at which the rays strike the patient. The optimum is the right angle. Then the patient receives 100 per cent. of the rays; but when the incident angle varies, there must be a compensatory increment in the time, so as to allow for the loss of intensity incident to the angle made by the rays striking the skin being less than 90°. The law governing this loss of intensity was first formulated by Lambert, and bears the name of the Cosine Law. The accompanying diagram gives the various angles that are usually used in practice, and also the increased percentage and time necessary for the production of an erythema, equal to that obtained when the ray is at a right angle. Compensatory time increments are shown round the circumference: *e.g.* 90°, no increment necessary; 75°, $\frac{1}{10}$ increment necessary. Thus if the time required at 90° is 60 seconds, then at 75° it would be $60+\frac{60}{10}=66$; at 60° it would be $60+\frac{60}{6}=70$; at 50° it would be $60+\frac{60}{4}=75$; and at 30° it would be $60+\frac{60}{2}=90$.

The worker in the field of ultra-violet radiation must ever be on his guard against many stumbling-blocks and traps that lie in his path. He will also assuredly encounter a host of errors, born of ignorance or prejudice.

To begin with, the very term "ultra-violet ray" is often improperly used. A common example of this is furnished by the trade descriptions given to those little monopolar high frequency electrode machines, which have such a large sale among the general public, and are to be found masquerading as "ultra-violet ray apparatus" in hairdressing establishments and Bond Street "beauty parlours." The colour which these instruments produce when a high frequency current is passed through a vacuum glass tube is violet, certainly, but it is certainly not the ultra-violet ray it often pretends to be, since this ray is invisible and will not pass through glass at all. Hence, whatever the therapeutic effect, real or imaginary, that may follow the

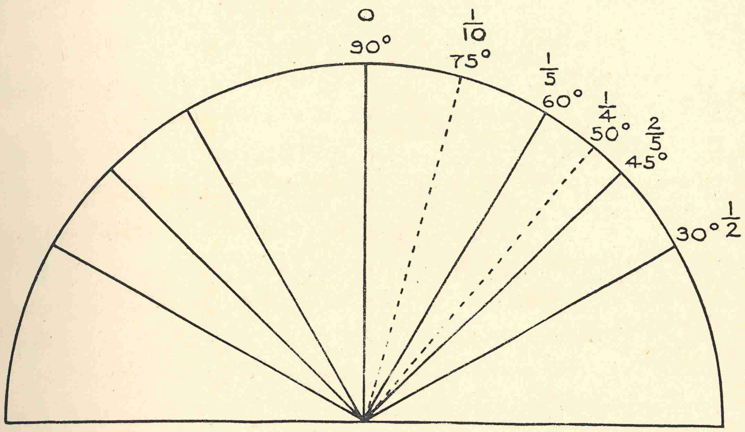


Fig. 3.—Diagram showing Compensatory Time Increments for Various Angles of Incidence of the Rays.

application of any apparatus of this description, it is emphatically not caused by the ultra-violet ray. To use these terms in connection with these machines is accordingly misleading, not to say fraudulent, and should be forbidden by law.

Conspicuous among the many errors into which workers who are commencing their study of actinotherapy are apt to fall, is that of talking (and thinking) too much of "burns." The general public who derive their medical opinions from newspaper paragraphs and scare headlines in the lay press are frequently harrowed by reading vivid accounts of "X-ray burns." Such injuries, however, do not exist in the realm of ultra-violet radiation elsewhere than in the imagination of uninformed writers. There may, of course, be actinic erythema, but this is very different from a burn. Similarly there may be a blister with the water-cooled lamp, either intended as a necessary treatment for a nævus or mole, or it may follow upon an overdose from an air-cooled lamp, and the best treatment for this latter is the exhibition of the 3000 candle-power lamp. Sampson, indeed, lays it down in his *Physiotherapy Technic* that "the very best treatment for any kind of burn, from X-ray burns, through the heat and chemical burns to sunburn, is properly administered actinotherapy."

Certain erroneous conceptions also are apt to be formed from the recorded views of various writers on heliotherapy. One is that the ultra-violet light, infra-red and luminous spectra, constitute three distinct categories. These writers also attribute to the infra-red, the property of raising the temperature; to the luminous, the property of being visible; and to the ultra-violet, the property of exerting chemical action when brought into contact with certain substances.

In the light of our increased present-day knowledge, however, these *ex cathedrâ* views are incorrect. Similarly it is wrong to apply the expression "chemical rays" to the ultra-violet rays. As Rollier points out in his reference to the "scientific basis of heliotherapy," the physico-chemical action of a radiation is largely dependent on the nature of the particular substance on which it acts. Hence it is quite possible to discover substances which absorb both luminous and infra-red rays, and thereby undergo definite chemical changes.

The majority of the constituents of living cells are without colour, and hence do not absorb rays of the wave length of visible light. A number of them, however, and in these are included living cells, do absorb ultra-violet light. The natural result is that radiations of this nature exert a definite and powerful effect on living cells. It is interesting to note that most authorities state that the excitability to ultra-violet rays is independent of temperature; but my personal experience is against this, and goes to show that the clinical effects are better in the summer than in the winter, and even that in a warm spell in the summer they are better than they are when it is cold and wet; and I have made use of this observation to precede the local applications of ultra-violet rays with an exposure to the high candle-power light.

This refers more particularly to local applications, and is probably due to the fact that the capillaries are more dilated in the warm weather (or by the high candle-power lamp) and thus expose a greater surface capable of absorbing the ultra-violet rays. But though it seem at first sight to be a paradox, as will be seen later, the room should not be too warm when giving the general body bath.

Another fallacy must be mentioned, and that is the oft-repeated statement that natural sunlight must be better than any form of artificial sunlight. In this connection Dr. Amstead, the surgeon at Rollier's institution at Leysin, in the Alps, writes in that classic in the realms of heliotherapy by Rollier, "Sun and ultra-violet rays bear much the same relation to one another as crude drugs do to their synthetically prepared chemical substitutes."

There are many rays in the solar spectrum which are not needed for therapeutic use, and many in fact are a drawback comparable with the deficiencies in crude drugs. If we wish to give a patient a drug to relieve pain, do we go and gather a handful of poppies, make a decoction of this, and order a mouthful to be taken at intervals? Or do we prescribe a hypodermic injection of morphine, an accurate dose of exactly that part of the poppy that is desired? It is this accuracy of dose in actinotherapy which makes for the superiority of artificial sunlight over Nature's best efforts. Another point in this superiority consists in the fact that from the lamp we get a greater intensity of ultra-violet rays.

I do not wish to be taken as saying that a dose of ultra-violet rays in London is better than a stay at Leysin, since in suitable cases the latter must be the counsel of perfection; for a stay at a mountain resort in a sunny, dry atmosphere at an altitude above the smoke and dirt will furnish the patient with many advantages apart from ultra-violet radiation which will contribute to his cure. Again, in such places as Switzerland, there is a constancy in the source of light which is a help to accuracy of dose, which is impossible here where the actinic power varies from day to day, hour to hour, and even minute to minute. Clouds of different composition and density filter out these rays, or block them almost entirely, for so great a proportion of the time that it is more scientific to rely upon artificial sunlight, which can be administered independently of climatic conditions.

Dorno has compared the intensity of the ultra-violet light with that of the sun at the mean altitude, and found it was:

At 100 cms. (40 in.)	distance	3·7-fold	sun's strength.
70 cms. (28 in.)	,,	6·1-fold	,,
50 cms. (20 in.)	,,	12·2-fold	,,

The latest form of lamps producing ultra-violet rays are proving so efficient in the hands of capable operators, and productive of such good clinical results, that they are getting a foothold even in the most up-to-date sanatoria, such as Alton, where exposure to artificial sunlight is the routine treatment. At Alton, as already stated, Sir Henry Gauvain is using mercury vapour, carbon, iron, and tungsten arcs. Here they may be seen as adjuvants in some cases; in others superseding the natural sun cure, and contributing each its share to the therapeutic armamentarium of the light treatment in accordance with the latest scientific knowledge and in the most accurate mathematical detail.

Despite the considerable volume of work done and progress already achieved by Bernhart, Eidenow, Finsen, Gauvain, Hill, Reyn, Rollier, Russ, Saleeby, Sequeira, Schunck, and Turrell, and numerous other experts, the possibilities of ultra-violet radiation as a therapeutic agent are still very far from being exhausted. The field, indeed, is so vast, that so far little more than its fringe has really been touched. We still lack an adequate scientific explanation of the reason why good results have often been secured with radiations that differ so much in respect of continuity, intensity, and range. We can, of course, compare the degrees of severity (or the reverse) of the erythema produced, by exposure to these different radiations. This, however, cannot be considered a completely satisfactory criterion.

Another point on which one seeks knowledge is the question as to why a carbon arc bath will produce an extraordinary revivifying sensation in one patient and not in another, or why this will occur in the same patient at one time and not at another. It is known that where there is sugar latent or manifest, ultra-violet radiation is contra-indicated; but where both blood and urine give satisfactory analyses, these apparently inexplicable results occur. It has been suggested that the relative acidity may be a controlling factor. It is to the future that we must look to clear up these, and other vexed points.

A strong point has been made by C. W. Sampson in his *Physiotherapy Technic*, when he says: "This subject ought to be, and very soon will be, taught thoroughly, in every medical school. . . . The field for the proper administration of these physical remedies is so large that I never expect to live to see the limits reached."

APPARATUS

CHAPTER III

APPARATUS

To get anything approximating efficient results with actinotherapy it is, of course, absolutely necessary that the physician should be equipped with a good armamentarium. The secret of success lies, above everything else, in the choice of the appropriate form of energy. It also goes without saying, that all the apparatus should be of the best possible quality, and of the most modern pattern. Then, too, it should be kept scrupulously clean (whether in daily use or not), and at regular intervals it should be returned to, or visited by, the manufacturers for expert examination and overhauling.

Again, as with every other portion of the medical man's equipment, so is it with this. To secure good results it is imperative for the physician to familiarise himself thoroughly with its possibilities and with the best procedure in application. Neglect of this precaution is merely asking for trouble. Incidentally, it injures the cause and good name of actinotherapy.

Ultra-violet radiation may be generated by either the arc or the spark discharge. Since, however, the latter does not give sufficient volume, only the former will be here considered.

As a preliminary, it is as well to observe that the apparatus from which is produced ultra-violet light for therapeutic purposes, consists fundamentally of an arc. This arc is formed by the electric current passing between two terminals, the result of which is to produce a very intense illumination. The illumination is composed of the invisible ultra-violet ray, together with various visible rays, among which are violet, indigo, and yellow, etc. The ray is cold, and therefore cannot burn the skin, though, as will be seen later, in lamps such as the air-cooled quartz lamp, the carbon and other arcs, heat is generated as part of the incandescence. This heat, if brought too near to the body surface, is quite capable of burning it.

The arc may be of either carbon, tungsten, or iron, or of a mixture of these and certain other elements. The arc may also be formed in a mercury vapour enclosed in a quartz tube.

The types of equipment in mercury arc lamps are commonly classified as air-cooled and water-cooled. The former pattern is generally adopted for systemic irradiation, or where large areas, such as chest or abdomen have to be irradiated, and the latter is reserved for focal or cavity work.

The air-cooled pattern furnishes a dominant excess of near ultra-violet intensity; and the water-cooled pattern a relative preponderance of far ultra-violet intensity. The intelligent selection of the type to use in each particular case

he encounters is thus among the first essentials for the physician in the treatment of a given condition.

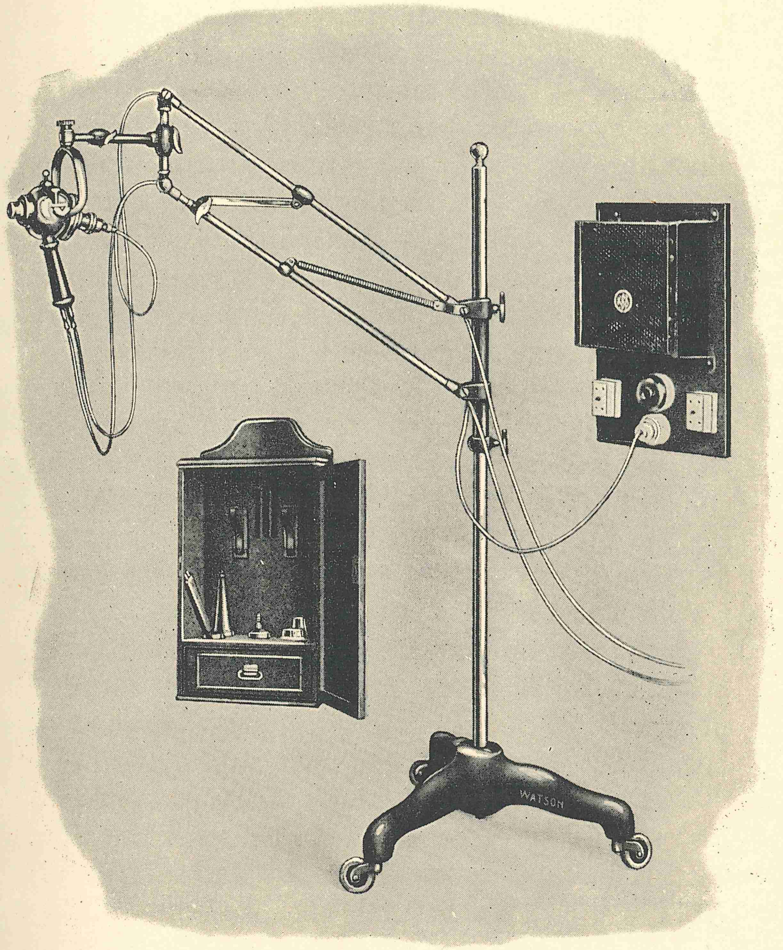


Fig. 4.—Water-cooled Mercury Vapour Arc Lamp.
(Manufactured by Kelvin, Bottomley & Baird, Krohmeyer Type.)

A water-cooled mercury vapour arc lamp in general use is that known as the “ Krohmeyer.”

In this, the ultra-violet radiations are applied by means of a series of quartz crystal transmitters, or compressors.

This type of lamp may be used for both internal and external treatment. The column of mercury is contained in a quartz tube mounted on the removable back plate of a water-cooled chamber. A quartz window closes the front of this chamber, and the radiation that emerges from it can either be used directly, or alternatively passed through another quartz element or transmitter. The construction is such that parts brought into contact with the patient can easily be sterilised. See Fig. 5.

In conjunction with the proper applicators the water-cooled mercury vapour lamp can be successfully used for internal treatment, though its use for external treatment is more general. Important advantages are the ease of its manipulation and its silent running.

Such a lamp has been found productive of good therapeutic results in a large number of specific diseases. It renders the treatment of cutaneous affections easy and rapid, and also allows the source of the luminosity to approach and almost to come into contact with the skin. The consumption of water with this lamp is from 4–4½ pints per minute, and the hourly expenditure of electrical energy is 500 watts. It has a regulating resistance by means of which the intensity of radiation can be varied. If either chalk or iron be present in the water that circulates through the lamp body the result is that both the window and the quartz jacket will become encrusted. This will lessen the efficiency of the lamp. The deposit, however, can be dissipated by washing the inside of the lamp body with a 5 per cent. solution of hydrochloric acid. Immediately after cleaning in this fashion the acid must be got rid of by rinsing with pure water. Should a leak occur in the vicinity of the quartz window it means that either the rubber gasket is defective, or else the ring nut is not on straight. If the former be the case, a new gasket is required. As long as the water-cooling is sufficient the lamp body will always remain

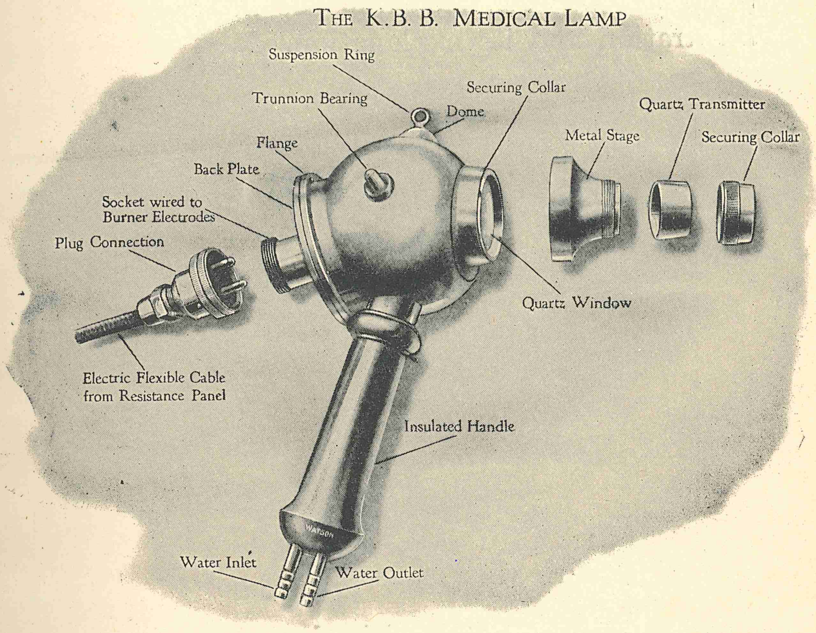

THE K.B.B. MEDICAL LAMP
Suspension Ring
Trunnion Bearing
Securing Collar
Dome
Quartz Transmitter
Metal Stage
Securing Collar
Flange
Back Plate
Socket wired to Burner Electrodes
Plug Connection
Quartz Window
Electric Flexible Cable from Resistance Panel
Insulated Handle
WATSON
Water Inlet
Water Outlet

FIG. 5.—THE WATER-COOLED MERCURY VAPOUR ARC LAMP; SHOWING PARTS.

water-tight. When, however, the cooling is insufficient, the surrounding cement will gradually become softened by warmth. Should a leak occur at the back of the lamp body, the lamp should be returned to the maker for repair.

An understanding of the air-cooled quartz lamp will be gathered from the accompanying illustration and its explanation.

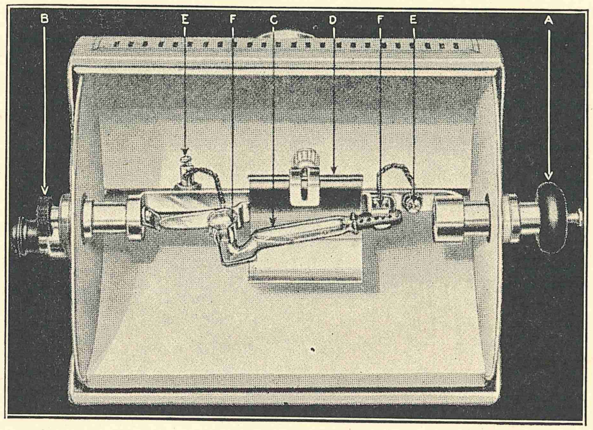


Fig. 6.—Air-cooled Quartz Lamp.
(The Victor Corporation, U.S.A.)

The illustration herewith shows the interior of the rotary casing. A "rocket" arm serves a double purpose, namely, to hold the quartz tube and as a tilting device for starting the tube. The electrical connections from the tube terminals are made at binding posts "E, E." To start the tube, the knob "B" is turned clockwise, which causes the rocker arm to raise the tube; with the result that the mercury in the tube flows toward the anode, completing the electric circuit, and strikes a mercury arc. After the tube is thus energised, it is returned to its original position by releasing slowly the knob "B." The arc in the tube is maintained until the current is turned off following the treatment.

By pressure on the button which forms a part of clutch-knob "A" the casing is released and can be rotated, completely or partially, according to the angle at which the operator desires to direct the rays from the tube.

Two other clutch-knobs, somewhat similar to "A" but not visible in the illustration, are placed on two of the casing segments, so that the opening can be varied to meet any requirement. Each of these segments or shutters is also provided with a diaphragm opening, directly in the path of rays from the luminous portion of the tube. Applicators can be instantly attached to these diaphragm openings and held securely, by an automatic locking device, during focal treatments.

"D" is an auxiliary reflector which, although not a standard part of each outfit, is frequently ordered as an important accessory. This reflector is for attachment to the stationary axis of the casing, immediately behind the tube, so that the rays can be concentrated into a smaller beam; this is very desirable in focal work, with an applicator attached to the diaphragm opening of the casing. It is often found useful also in general work, without applicators, where quicker results are sought over a limited area. The reflector can be rotated on the casing axis to an angle of 90°, *i.e.*, to project the rays at any angle through the opening between casing segments.

The clamps "FF" holding the tube, also serve to make the electrical connection.

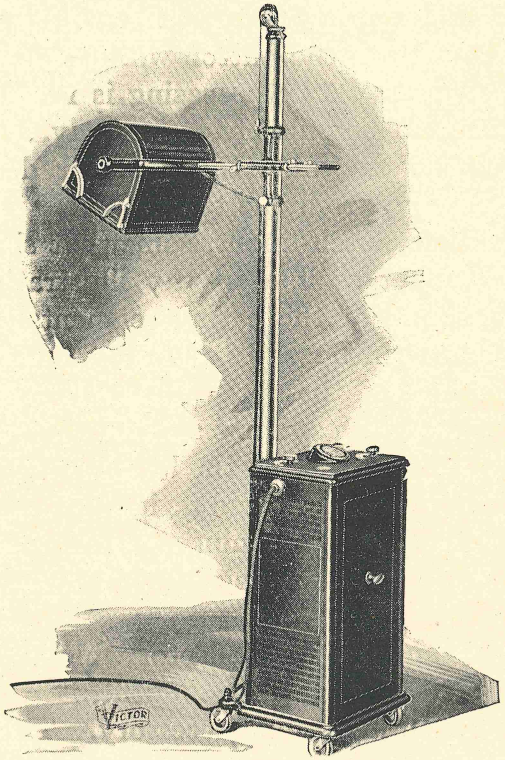


FIG. 7.—AIR-COOLED LAMP.
(The Victor Corporation, U.S.A.)

Should the medical man, who wishes to instal both air-cooled and water-cooled lamps, have only a limited amount of space at his disposal for this purpose and find it necessary to economise in this respect, he can equip himself with a combination outfit that is on the market.

A number of these are now procurable. One of their advantages is that they require only a single control auxiliary. As a result, each lamp can be operated independently of the other. This control may be either by rheostat or rectifier. The rheostat is the auxiliary for the mercury quartz tube, when operated on direct current supply. The voltmeter with which it is equipped indicates the operating efficiency and enables the dosage to be measured accurately. The rectifier is the auxiliary for the mercury quartz tube when operating on alternating current supply. In addition to a voltmeter, etc., it is equipped with an intensity switch providing a convenient means for the voltage regulation. If the physician's practice be such as to require a separate treatment room for each lamp, an additional control can always be installed. This is not a difficult matter, but it is more satisfactory to have the two lamps, each with its own control entirely separate.

When air-cooled lamps are employed, comparatively large areas may be treated with a single exposure. It is necessary, however, to keep the light at a minimum of eight inches from the actual surface of the skin. This is because the lamp generates a high degree of heat. In fact it becomes incandescent, and should an incandescent body be brought too near the skin a bad *heat*-burn is sure to result. Whereas, as has been seen when water-cooled lamps are employed, the quartz tubes, being wrapped in a protecting jacket of running water, can be brought quite close to the skin without causing an injury.

A necessary word of warning should be given. With a new Krohmeyer lamp, care must be taken to standardise it. When this is not done the physician is unable to determine the proper lengths of exposure giving the various degrees of erythema required for therapeutic use. The appropriate method of standardising this lamp will be described in detail in the Chapter on "Technique of Treatment."

The preceding remarks upon the relative value of water-cooled and air-cooled lamps in the therapeutic employment of ultra-violet radiation are intended to provide a field of research in this direction rather than to enunciate definite and precise laws for their technical application.

In summing up this subject, the following special points should be carefully noted:

The output of ultra-violet radiation is in inverse proportion to the age and amount of use of a (quartz mercury arc) lamp. The intensity emitted is gradually reduced by the formation of a thin metallic deposit on the inside of the tubes. The average period of the life of the 220-volt arc lamp of this type is between 2500 and 3000 hours. It should be noted that in some cases the intensity of the ultra-violet radiation can be increased by using quartz lenses to focus the image of the source.

TUNGSTEN ARC LAMPS

The tungsten and carbon arcs should now be considered.

In the days of my early practice with artificial light, my chief stand-by was the tungsten arc. The first hundred cases that came to me of wounds, trench feet, indolent ulcers, and various inflammations of the cutaneous tissue which had presented difficulty in healing, were all treated by it. Before, however, describing the tungsten arc, I propose to say a few words about the Simpson light.

During the war an arc light was given a certain prominence and very extravagant claims were advanced for it. The electrodes were made of metal, the composition of which was shrouded in mystery, and the therapeutic effects of which were to rank with the seven wonders of the world. Anxious as all medical men were to aid the wounded soldier, we gave these lamps a very fair trial in some of the military hospitals. Gradually the mystery surrounding the metal was dispelled. Dr. Russ of London and Mr. C. A. Schunck of Ewelme found that this metal yielded a tungsten spectrum mixed with iron lines. Next, Dr. Sequeira investigated this arc from the clinical point of view. About the same time Major Turrell, who was then, and still is, electro-therapeutic physician to the Radcliffe Infirmary at Oxford, had made for him highly compressed rods of pure tungsten and began to do some original work with this agent. It is to him that we are to-day largely indebted for our knowledge of, and practical apparatus in use with, the tungsten arc lamp.

The tungsten arc lamps are made in a variety of patterns. In general they are similar to such ordinary arc lamps as are used in cinematography. The electrodes are rods of pure tungsten. An ammeter and a resistance are connected in the circuit. The arc is quite open and the rays are focused by means of a concave reflector of polished copper, which absorbs fewer of the rays than does the ordinary mirror reflector. If desired, the light may be confined to a small area by passing it through a quartz lens 2 inches in diameter with a 4-inch focus. (Fig. 8). This is mounted in a circular frame which should be of sufficient size to protect the area surrounding the part under treatment. A long handle is mounted on the frame. In addition to the pieces of apparatus already mentioned, several pairs of No. 2 Crookes' glass spectacles with hooded frames are required for the protection of the eyes of the patient, operator, and assistant. The lamp is operated on direct current and should be capable of consuming ampères 15 at volts 100.

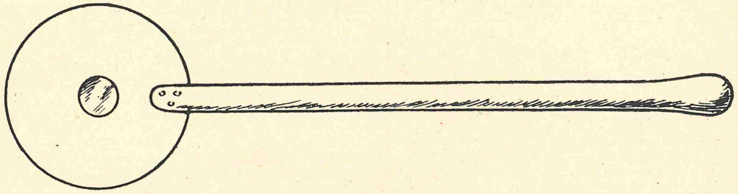


Fig. 8.—Quartz Lens in Protective Frame.

The part to be exposed should be placed about 12 inches from the arc and the rays focused by the reflector or condensed by the lens.

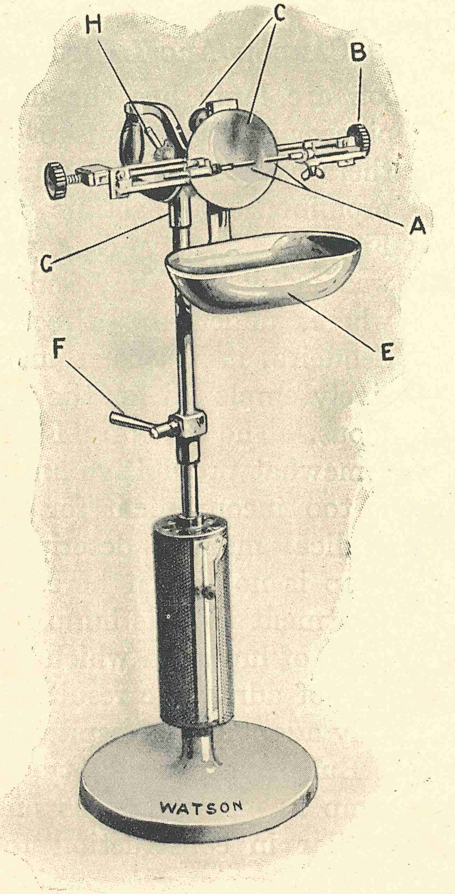


Fig. 9.—Tungsten Arc Lamp as Designed by Dr. Percy Hall.

A. Paired Tungsten Electrodes; *B.* Paired Milled Heads for fine Adjustment of Feeding Mechanism; *C.* Mirror, interchangeable with Shield *D*; *E.* Splutter Bowl; *F. G. H.* Mechanical Adjustments of Lamp as a Whole, Height, Rotation, and Tilt respectively.

A more modern type of a tungsten arc lamp has been designed by Dr. Percy Hall of Hull, and made from his specification by Messrs. Watson & Sons (Fig. 9). It has the resistance fixed so as to allow 5 ampères of current to pass across the arc.

Carbon Arc Lamps

The carbon arc lamp has the distinction of being the pioneer in the realms of ultra-violet therapy. It was first brought into prominence in actinic therapy by Finsen. Twenty-four years ago it was installed at the London Hospital, where, under the direction of Dr. Sequeira, it has been, and is, extensively employed for the treatment of lupus. The cost of a Finsen lamp is somewhat prohibitive and, as its size is too inconvenient for the average medical man, a description of this lamp is not given here. Since, too, treatment by this lamp is limited to cases of lupus (in which it is productive of admirable results), it is really only adapted for hospital use.

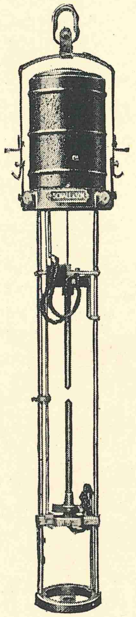


Fig. 10 — Carbon Arc Lamp.

But a very useful type of carbon lamp in general use is one which is similar in construction to that employed for cinematograph projections. Its main features are a pair of carbons and an electric self-regulating mechanism with a switch-board and ammeter. These lamps are of different amperage consumption, such as 6, 20–25, 50, and 75. The accompanying illustration is of a 20-ampère lamp.

Although not so rich as the tungsten and mercury vapour arcs in the far ultra-violet radiation, the carbon arc type of lamp has great penetrating power and also emits intense radiation in the near ultra-violet region.

It is advisable with these lamps to use direct current. This is because a crater is formed on the positive carbon, and this is the source of the most intense radiation. When alternating current is used, a point is formed on each carbon electrode and the intensity of the radiation is decreased.

There is an arrangement whereby the positive carbon is rotated by a motor, and this increases the radiation. Up to the present it is used in the cinematograph world in a lamp consuming 70 ampères; but it would seem that it should be used where several patients are to have the general body treatment at the same time. So that the extra efficiency so obtained would be available for the suffering public as well as the frequenters of the film theatres.

When carbon arc lamps are used, it is advisable that they should be capable of being raised and lowered as required, and it is more convenient that the positive pole be vertically above the negative. The therapeutic rays are evolved from the crater that is formed in the end of the carbon forming the positive pole.

For the general body bath I have been using two installations, one consisting of two arcs, one at the back and one at the front of the patient, and a mercury vapour lamp on one side. These carbon arcs were originally used for lighting work in film producing, and loaned to me by Messrs. Duncan, Watson & Co. The electrodes are made of carbon impregnated with mercury. The skin-arc distance is 24 inches, and the skin-quartz distance from 4 to 5 feet. The treatment commences with an exposure of fifteen minutes for the carbon arc, and half that time or less for the mercury vapour lamp, and the patient is instructed to turn round when he has had half the exposure of the mercury vapour lamp, and by this means he will get the appropriate dose from both sources of radiation. The time of exposure should be increased at each sitting, as has already been explained.

The other installation may be thus described. Briefly it consists of six lamps so arranged that three irradiate the back and three the front of the patient.

It has been specially designed for therapeutic work to give the greatest possible intensity of ultra-violet radiation, with the mechanism so arranged as to give a uniform field of illumination free from shadows. The illustration on page 51 shows three such lamps, *i.e.* one half of the apparatus, suspended in a skeleton frame arranged so as to hold them in the most convenient position, namely, about 3 feet from the floor and 2 feet 3 inches apart. Thus arranged, in hospital work two recumbent patients can be treated simultaneously, one on either side of the line of arcs; but in private practice, where patients are usually treated singly, the exposure can be shortened, as I have said, by using two such lines, one on either side of the patient. When used in this way the suspension frames are set about 4 feet 6 inches apart, with the couch between.

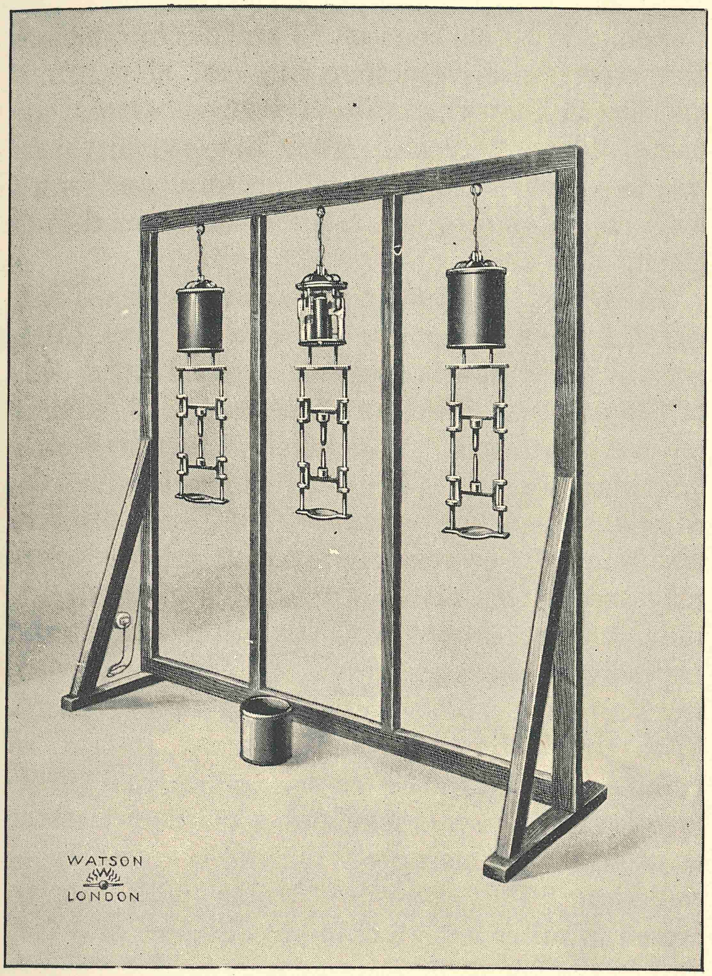


FIG. 11.—CARBON ARC LAMP. DOUBLE-TRIPLE.

The lamps in my own practice are arranged thus: the three lamps in each line being connected in series, and the two lines in parallel, each line being fitted with a resistance and switch. With carbons of 13 and 20 millimetres diameter respectively they run best at approximately 20 ampères, with a voltage across the arc of 45 to 50 volts. They are automatic in action—that is to say, self-feeding, and work with a minimum of trouble and maximum effect.

The latest appliance for carbon-arc treatment, which I have but newly installed as this edition goes to press, consists of four arcs on either side of the patient. Each of these four arcs forms a self-contained unit. The whole is mounted on a floor stand, which is fitted with three large castor wheels. Each unit has a radiation value of 20,000 candle-power concentrated on the necessary area. One advantage of this apparatus is that it does away with the cumbersome and expensive resistance which is necessary when working from a high voltage (200 volts) current. With this arrangement the current, instead of being consumed in the resistance box, and therefore from an economical point of view wasted, is used in producing an increased quantity of radiation. The exposure begins with ten to fifteen minutes with a skin-arc distance of 4 feet and is then increased in subsequent treatments according to the degree of pigmentation produced. This increase should be from three to five minutes on each occasion until from thirty to forty minutes' exposure be reached.

The lamps illustrated in Figure 12 are made by Messrs. Arnold and Sons, of London.

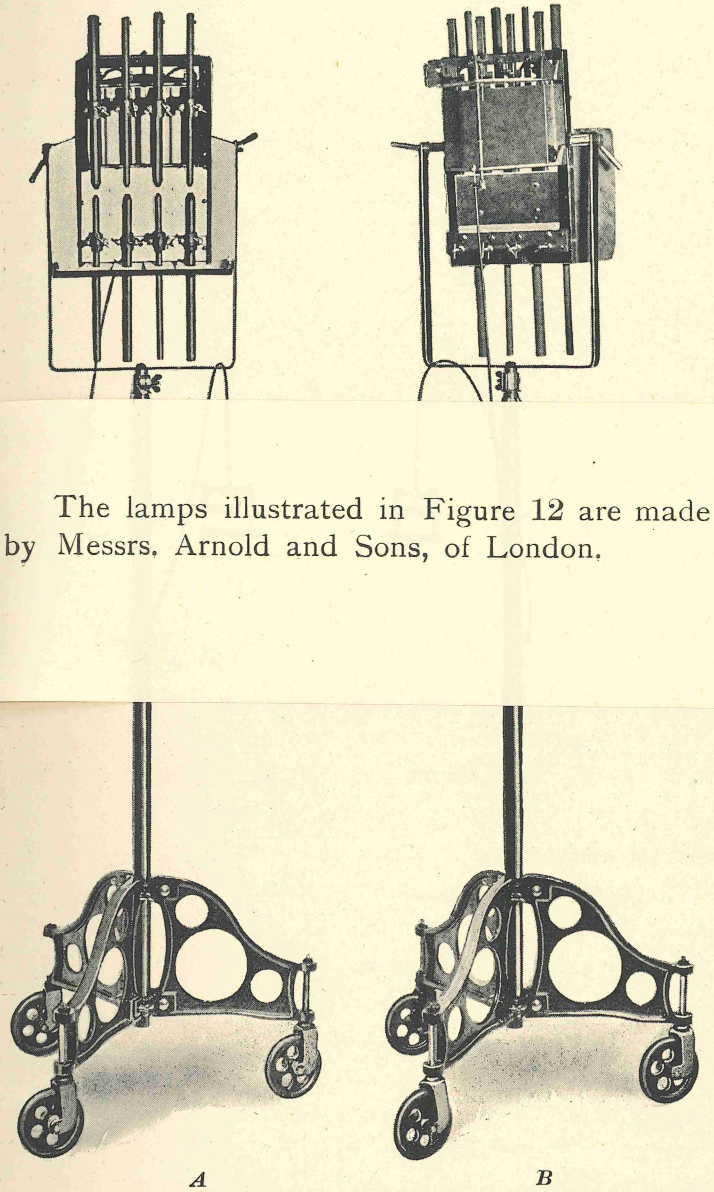
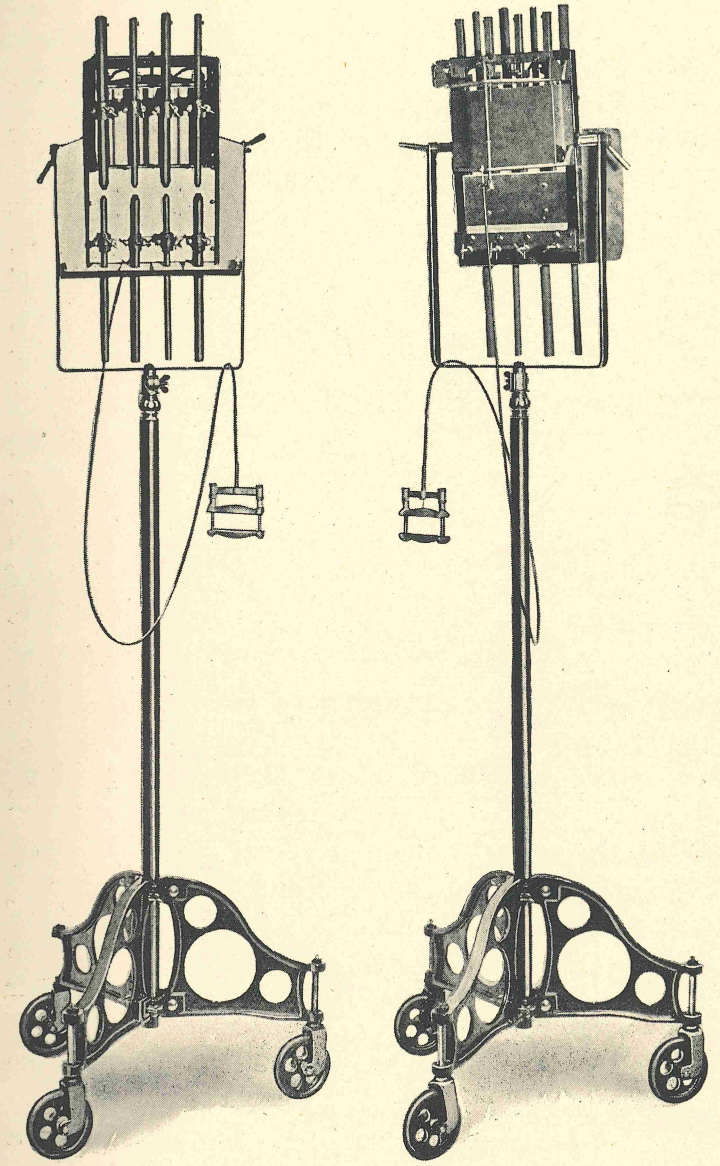


FIG. 12.—CARBON ARC LAMP. DOUBLE-QUADRUPLE.

thus: the three lamps in each line being connected in series, and the two lines in parallel, each line being fitted with a resistance and switch. With carbons of 13 and 20 millimetres diameter respectively they run best at approximately 20 ampères, with a voltage across the arc of 45 to 50 volts. They are automatic in action—that is to say, self-feeding, and work with a minimum of trouble and maximum effect.

The latest appliance for carbon-arc treatment, which I have but newly installed as this edition goes to press, consists of four arcs on eith [illegible] of the patient. Each of these fo [illegible] self-contained unit. The [illegible] floor stand, which [illegible] wheels. [illegible] [illegible] current. [illegible] current, instead of [illegible] resistance box, and therefore [illegible] economical point of view wasted, is [illegible] in producing an increased quantity of radiation. The exposure begins with ten to fifteen minutes with a skin-arc distance of 4 feet and is then increased in subsequent treatments according to the degree of pigmentation produced. This increase should be from three to five minutes on each occasion until from thirty to forty minutes' exposure be reached.



A *B*

FIG. 12.—CARBON ARC LAMP. DOUBLE-QUADRUPLE.

Iron Arc Lamps

The iron arc lamp is very rich in ultra-violet radiation. It contains some specially intense lines ; but the spectrum is less continuous than in that of the tungsten arc, and it only extends to wave lengths of 2250 Å. In the tungsten arc the spectrum extends to about 2000 Å and shows an almost continuous band of emanations, much greater in density than that shown by other arcs mentioned, and rich in rays of short wave length. It is comparatively little used.

In conclusion, the question is often asked whether the arc light or the quartz mercury vapour lamp should be employed. There is no doubt that in order to meet the large variety of diseases and conditions which presents itself, no equipment can be considered satisfactory that does not include each type of lamp. Speaking very generally, the mercury vapour lamps are suited to the superficial conditions, the arc lamps to the more deeply seated maladies and systemic pathological conditions.

For the general body bath, which is the most generally useful weapon in the armoury of ultra-violet therapy, experience leads me to prefer the carbon arc to the mercury vapour lamp.

It has been stated that the rays from the carbon arc are more like solar radiations than those obtained from any other sources, and a comparison of the accompanying illustrations will show that the spectrum of the carbon arc is

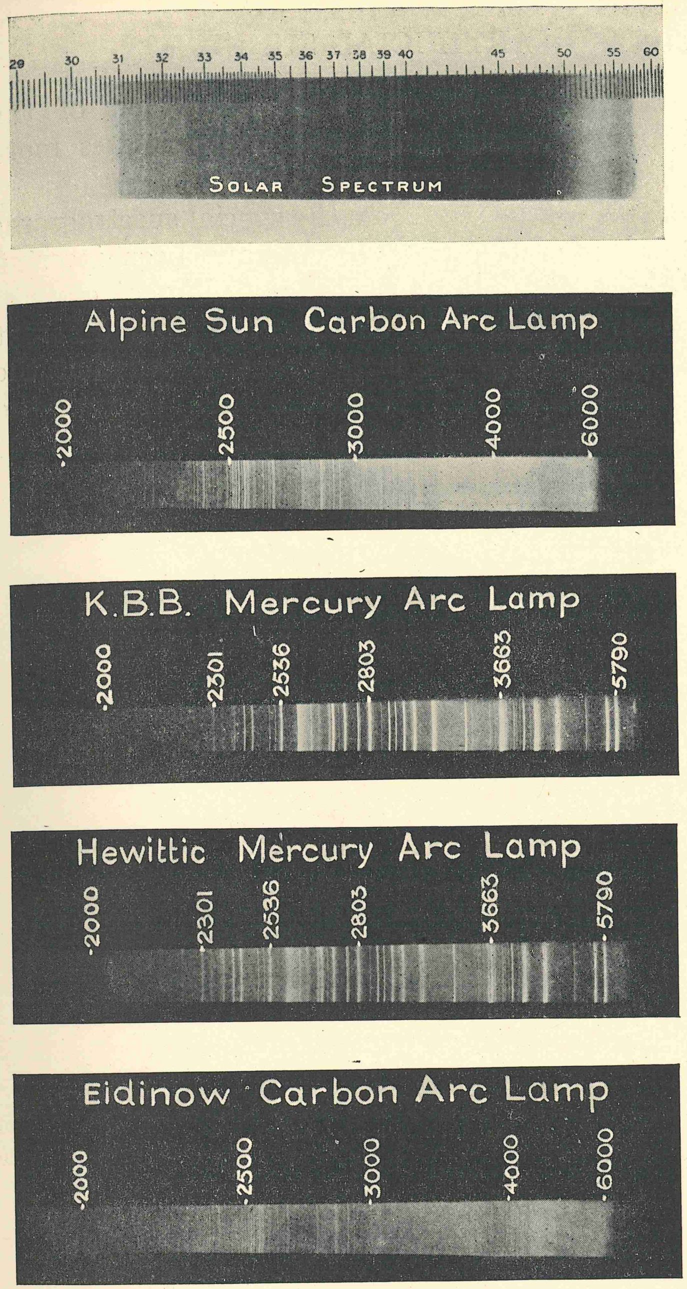


Fig. 13.—Spectrograms showing Comparison between the Solar Spectrum and the Spectra given by the Mercury Vapour and the Carbon Arc Lamps.

more continuous and even than that of the mercury vapour lamp, and approximates more closely the solar spectrum.

This will be seen from the special spectrograms taken for this work which have been inserted (Fig. 13) in order to show the different class of spectra which may be expected from different types of lamp. It may be mentioned that the possession of a pocket spectroscope gives one the means of making a rough estimation of the light any lamp is giving at a particular moment.

THE THERAPEUTICS OF THE ULTRA-VIOLET LIGHT

CHAPTER IV

THE THERAPEUTICS OF THE ULTRA-VIOLET RAYS

For over thirty years the therapeutic value of ultra-violet radiation has been known; but the exact manner in which these rays exert their beneficent action has yet to be explained.

In 1891 Finsen pointed out that the blood in the capillaries absorbed actinic rays. These rays have their effect upon lymph and blood channels. The glandular tissue is also affected and its phagocytic power increased.

This is comparable with the action of sunlight, the effect of which is to improve the vitality and increase the immunising power of the body. In brief, ultra-violet rays assist the development of antibodies. In a way, therefore, they may be said to be antigenic and capable of destroying bacteria within the body. This is one of the clinical effects of ultra-violet radiation. It is not perhaps the most important, because the shorter and more lethal rays have the less power of penetration.

As long as tissue radiation, which is strong enough to extend to every portion of the area under treatment, can be produced in the same locality, it is unnecessary that the ultra-violet ray should reach the whole area to which it is being applied.

The most valuable result of these rays is the hyperæmia produced by a properly regulated dose. Manifesting itself six to eight hours after exposure to the light (the latent period), the hyperæmia will remain for a period varying from two days to two weeks. This effect should be more particularly noted when it is being considered in what diseases ultra-violet therapy should be employed.

The pathology of the hyperæmia produced by the light is as follows. On microscopic examination the skin shows serous swelling in the deeper layers of the cells of the epidermis. The diameter of the vessels in the skin may double or even quadruple in size and the blood slow down and the circulation come to a standstill. Twenty-four hours after there is visible œdema and active diapedesis from the deeper non-thrombosed vessels. The thrombi are removed by phagocytes. When the exudation is sufficient to break continuity between the horny and granular layers of the epidermis, blister will result (Hill).[1]

For the cause of the hyperæmia we have to fall back on theory ; and the theory is based on the fact that it is possible by means of ultra-violet rays to obtain a photograph of the dividing nuclei of a cell. That is to say, the chromatic

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[1] *Sunshine and Open Air*, Leonard Hill (Edward Arnold & Co.).

substance of the cell absorbs the ray. (Light cannot act unless it be absorbed—*vide* Grotthus' law.) This absorption splits up the chromatin, and possibly also liberates some toxin, which stimulates an increased blood supply. Such a theory would account for the latent period and the subsequent hyperæmia.

The result of this hyperæmia, however induced, is one of the principal therapeutic effects of ultra-violet radiation. Following upon the hyperæmia we get a bronzed skin tint, such as is often noticeable on people who have recently returned from a prolonged voyage or holiday in sunny weather. Such bronzing is caused by the presence of melanin granules. These granules form a screen round the nuclei of the skin and basal cells, and thus protect them from an overdose of ultra-violet rays.

Thus Nature, by means of pigmentation, has provided an automatic defence against an overdose of light. All patients do not pigment to the same degree, and the extent, or otherwise, of this pigmentation, has an important bearing on prognosis. Patients who do not pigment well, do not benefit so markedly under the treatment. Possibly the power of pigmentation or tanning is an index of their powers of resistance. Hill and Gauvain adopt this view in cases of surgical tuberculosis. Pigmentation may be, and I am inclined to think that it is, a reaction in some way related to endocrine balance, and this relation offers a promising field of research and may be of great benefit to those who are working in the field of endocrine and auto-endocrine therapy.

As to the actual use of the pigment, it is, as has been said, primarily a screen and a means of converting light into heat, which is then sweated away. Rollier goes a step farther and regards it as a transformer of light energy into energy which is expended in some chemical action useful in defence. But it is as a screen that its utility is greatest. Experimentally this can be demonstrated by isolating melanin (obtained from eyes of oxen) as a fine powder and mixing it with water. The resulting mixture or suspension protects the palm of the hand from the sun's heat as concentrated by a burning glass. The water is evaporated by the energy which the pigment absorbs and converts into heat. From this we note how the pigment serves to protect the deep layers. The conversion of light into heat stimulates the natural sweat glands. The damp skin, with pigment underneath it, acts in the same fashion as the suspension of pigment and water.

The therapeutic action of ultra-violet radiation on metabolism opens up a wide field. It is known that these rays are absorbed by the blood; but we do not know how they are stored, or in what manner or form they are set free in the tissues. But that metabolism is profoundly and beneficially affected by them is now established beyond doubt. The good effect may be due to the chemical changes in the blood which follow the administration of ultra-violet rays. One of these changes is that the calcium content becomes higher, and another is that the concentration of inorganic phosphorus is increased by its means.

The phosphorus and calcium increase in the blood is probably due to the absorption of these salts from the bowel, and the theory has been advanced that this absorption is enabled to take place by the lessening of the microbic infection. It also suggests the administration of phosphorus and calcium by the mouth during the therapeutic application of the light.

The phosphorus may be prescribed as Phytin, gr. iv, or the Syr. Glycerophos. Co., B.P.C., ʒi. The calcium as Collosol Ca., ʒi, or as tablets of calcium sodium lactate (a double salt of calcium lactate and sodium lactate sold under the trade name of Kalzana), gr. viiss. The glandular extract of parathyroid or some pluriglandular preparation may be added to the prescription, remembering that ultra-violet radiation stimulates the endocrine glands, and that by the oral administration of extracts of these and of the mineral salts, a greater amount may be expected to be assimilated by the body. Ultra-violet radiation increases the calcium and phosphorus content by abstracting these salts from the bowel, and it would therefore seem to be a logical corollary that if one introduces an additional quantity into the bowel the greater will be the opportunity for the process to abstract it therefrom and pass it into the general circulation.

It is probably mainly due to these chemical effects that ultra-violet radiation is productive of such good effects in rickets. This disease has been prevented and checked in many cases by the use of ultra-violet rays. Rats kept in darkness and deprived of certain food factors, notably vitamins, will develop rickets. If some of these rats are exposed to ultra-violet radiation, the development of rickets in them is checked. The calcium and phosphorus content in the blood is responsible in a great measure for the integrity of bone structure and the growth and calcification of the skeleton; and the effects of ultra-violet radiation are in many respects similar to those observed when cod-liver oil is being regularly administered. In this connection it is interesting to note that Huldschinsky in 1919 placed it on record that at the Oscar-Helene Home for curing crippled children at Berlin, artificial ultra-violet radiation was more effectual than sunlight and cod-liver oil. He says "Cod-liver oil as well as sunlight were found to be decidedly slow in their action, the exposure to ultra-violet light yielding incomparably better results."[1]

Experiments with ultra-violet light on animals will illustrate the close relationship between light and diet in the ætiology of rickets, and show how the chemical changes affected by radiation produce good results. When the diet remains a constant, standard, rickets-producing diet, rickets will either develop or not, according

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[1] *See* Bibliography.

to the dosage of light. Thus it was found that raying for two minutes daily with the mercury vapour lamp at a distance of 3 feet afforded protection. Raying for only one minute was insufficient. Four minutes sufficed when a carbon arc lamp was used at this distance, but two minutes were not enough. There can be little doubt but that the same reciprocal relationship between light and diet prevails in regard to infantile rickets.

To sum up so far, then: In addition to causing an increase of calcium and phosphorus in the blood, ultra-violet rays produce inflammatory reaction and determination of increased blood, lymph, and lymphocytes to the part treated, and also changes the immunising power of the body. The result is that a general exposure of the diseased part is more effective than a local exposure. This is because more blood is then brought under the influence of the light's action.

A very striking table is set forth by Hill showing the percentage of calcium and inorganic phosphorus concentration of the serum of rachitic children before and after exposure to light. The figures are in milligrammes per hundred cubic centigrammes of serum.

Some two years after this table was presented, very interesting results were published[1] of research work undertaken by Grant and Gates of the Rockefeller Institute. These bear out Hill's figures in a remarkable manner. The

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[1] *The Lancet*, May 3, 1924.

CALCIUM AND INORGANIC PHOSPHORUS CONCENTRATION OF SERUM OF RACHITIC CHILDREN BEFORE AND AFTER EXPOSURE TO SUNLIGHT.

1922.	Calcium.	Phosphorus.	Product.	
From June 6 to Aug. 2	8·8 11·1	2·8 5·0	30 50	Marked rickets. Definite healing.
From Aug. 8 to Aug. 24	11·0 11·2	3·0 6·9	33 66	Moderate rickets. Healed rickets.
From Aug. 11 to Sept. 9	10·6 9·2	3·0 5·9	32 54	Rickets. Healed rickets.
From Aug. 11 to Sept. 7	9·3 9·8	2·8 6·4	26 64	Active rickets. Definite healing.
From Aug. 16 to Sept. 7	9·3 9·8	2·5 5·9	23 58	Rickets. Healing.
From Aug. 18 to Sept. 9.	9·8 9·2	2·5 6·5	25 60	Marked rickets. Definite healing.
From Aug. 21 to Sept. 7	7·9 9·0	3·1 5·1	25 46	Rickets. Healing.

experiments consisted in exposing light-coloured, or albino, rabbits, to ultra-violet radiation for half an hour daily at a distance of one metre. The rays caused erythema with its usual sequelæ, desquamation and moderate pigmentation. The examination of the calcium metabolism gave the following results. It was found that the average concentration in the groups having been exposed to ultra-violet radiation for five, six, and seven weeks, was over 12·7 milligrammes per 100 cubic centigrammes of serum, as compared with an average of 11·9 milligrammes per 100 cubic centigrammes for sixty normal control rabbits.

In another set of experiments rabbits were given increased exposures of ultra-violet radiation daily over a period of four weeks, and in these animals the blood calcium concentration rose from 11·9 milligrammes per 100 cubic centigrammes of serum before exposure to 12·2 milligrammes on the twelfth day, 13·5 on the twenty-second day, and 12·9 at the end of the experimental period.

It was noted that the later figures in both these sets of experiments showed a somewhat lower level in the calcium content. This is probably due to the protection afforded by the skin pigmentation caused by the ultra-violet light.

These experiments show a further point of interest which has a distinct bearing on the subject and to which I will briefly refer. It is this. The weights of the endocrine glands and testes all increased during the treatment. These were all recorded and the changes compared with the normal controls. The parathyroids showed the greatest hypertrophy, the percentage in their increase varied from 14·1 to 51·1 per cent. This increase in weight was due to a true hyperplasia of the parenchymatous tissue. The normal relationship between the parathyroids and calcium metabolism is already established, but these experiments are important as showing the effect of ultra-violet radiation upon them both and, as the authors say, whether the light acts primarily on the absorption and excretion of calcium, and so causes a rise of the blood calcium which results in a hypertrophy of the parathyroid gland, or whether the radiation primarily affects the glands themselves, remains to be determined. But this determination may rest for the present. The fact of paramount importance is that ultra-violet radiation has the power to raise the calcium content in the blood, and is a reliable therapeutic measure which will cure and prevent rickets.

The importance of a high calcium content in the blood has only been recently recognised. As a student one heard much about proteins, fats and carbo-hydrates, but not that calcium, among the salts, was an essential necessity of nutrition. Experiments have shown that with a calcium deficiency, capacity for work is lowered, physical fatigue easily occurs, and the patient's liability to disease much increased; whereas with the raising of the calcium content the vital capacity of the organs is augmented and forms a factor in the general well-being, and constitutes a power to resist the invasion of disease.

Another and perhaps better known effect of calcium is that of increasing the coagulability of the blood, and apart from its use in those diseases which are associated with deficient blood coagulability, surely a course of ultra-violet radiation is indicated as a preparatory measure before operation in patients suffering from diminished coagulation power of the blood. In fact, if it be admitted that ultra-violet radiation raises the calcium content in the blood, and the manifold

therapeutic uses of calcium remembered, the urgent need of well-nigh universal application of ultra-violet therapy (if for this action only) needs no argument.

But other changes coexist with these beneficial effects, an important one is an increased activity in the vitamins of the body as a result of ultra-violet radiation. This has been proved by Mellanby.[1] Ultra-violet radiation has not the power of creating any vitamin, but it strengthens the action of the fat-soluble vitamin A, which is already in the body, or which may be administered to the patient concurrently with the radiation.

That the ultra-violet light has strong bactericidal action was proved as far back as 1890, when Robert Koch showed the great sensitiveness of the tubercle bacillus to light. Bacilli in sputum spread out on a thin film or glass slide are killed in ten minutes, and while opinions are divided about the effects of long wave-length radiations, they are united in recognising the powerful bactericidal power of short ultra-violet rays. Moreover, the lethal action of light is not limited to the bacteria, but it affects also their products and secretions, especially when these occur in a sufficiently dilute solution.

In a paper with the title of "Remarks on the Effect of Light on Bacteria and other Organisms," by A. Downes and T. P. Blunt, published in the *Proceedings of the Royal Society* of December 26, 1877, to which reference has already been made, one of the earliest mentions was made of the lethal action of ultra-violet rays on bacteria.

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[1] *British Medical Journal*, May 24, 1924, p. 895.

In a letter to *The Lancet* (June 21, 1924), Hill mentions the fact that the hæmo-bactericidal power of the blood is increased by exposure to ultra-violet light. This has been tested by himself, Colebrook, and Eidinow. Hill testifies that not only have surgical tuberculosis and cases of lupus benefited very considerably from such baths, but also that several women of sedentary indoor occupations, who were suffering from sciatic or "rheumatic" pains, have benefited similarly. Cases of duodenal ulcer (beyond the reach of these rays), which are not doing well on ordinary dietetic treatment, much improve from an application of ultra-violet light; and it is by considering the changes in the blood which the rays induce that we can see why this should be so.

Two paragraphs from this letter are instructive:

"Perhaps the most interesting and surprising case was that of a man, aged 54, suffering from high blood pressure (220 mm. Hg. systolic), breathlessness on climbing stairs, fainting attacks, frequent headaches for three years, and irritability. He had no sign of syphilis or renal disease, and had been previously treated in accordance with the best current medical opinion. Thus he ate little meat and generally restricted his diet, neither smoked tobacco nor drank alcohol, gently exercised himself in the open air and had hot baths. Nevertheless his symptoms had continued unabated. After starting the arc-light baths his headaches vanished, and now, after two months, his symptoms have all gone, together with about 2 stone of his overweight; his systolic pressure has fallen to 175 and he feels a different man."

"Another striking case is that of a girl 16 years of age, ill in health, with approximately a 50 per cent. increase of lymphocytes, diminished polymorphs, a few myelocytes in her blood, the hæmoglobin down to 75 per cent.; the abdomen somewhat distended, and a few glands in the right iliac fossa; while some grave disease of the blood-forming organs was considered possible, a doubtful diagnosis of tuberculous peritonitis was made. This girl, together with her blood, has been put into a healthy condition by a two-month course of general arc-light bath."

The letter closes by pointing out that in our cities we lose much ultra-violet radiation on account of indoor occupations and amusements, by screens of glass, smoke, and clothing. There is also the fact that the ultra-violet rays, especially in the winter months in this climate, are naturally weak. Ultra-violet rays are the natural stimulus of that great metabolic organ formed by the living cells of the epidermis.

Hence, by administering ultra-violet radiation artificially made, a very great benefit is given to a variety of sickly people; and, I think, not only is it certain, as Hill predicts, that, in two or three years' time, artificial sunlight will become general as a winter pick-me-up; but that those who have once realised the salutary effects of artificial sunlight will not limit its benefits to the winter time, but will rather make a habit of it throughout the year.

In addition to the therapeutic changes already noted, Saleeby says that he and numerous observers find that light raises the iron content of the blood, that it augments the iodine content of the thyroid, that it specifically raises the temperature of the blood as distinct from that of the body, that it increases the number of blood platelets (*vide infra*); and Gauvain has noted at Alton leucocytosis following upon heliotherapy. In the United States this last has been thoroughly well examined and proved.

Sampson's practice in producing a leucocytosis is to begin by employing the shorter rays over large areas. After four or five days' interval he then treats daily at a distance of from 20–40 inches. When the leucocytes have reached a level line, he closes up and repeats the cycle. The typical leucocyte curve is a drop in the count for a few hours, followed by a rebound to the starting-point. This continues upwards for about five days. After this, the curve descends rapidly at first, and then more slowly. The base line is reached in from eighteen to twenty days. On the tenth or eleventh day a secondary rebound may be met. This, however, does not reach the peak, and seldom lasts more than a couple of days.

Not all cases thus treated will show a leucocytosis; but its absence, after a general exposure such as outlined, is a very good evidence of lowered reactivity, or the overwhelming presence of toxins interfering with the reaction. There are also cases which fail to show leucocytosis at the beginning of treatment, but which do show it after a few weeks of tonic raying. The moral of this is obvious.

Before leaving the general therapeutics of the ultra-violet ray, one or two observations on its action locally should here be given. Thus, tuberculin, which has been exposed to ultra-violet radiation, loses its power to produce intradermic reaction, and toxins of diphtheria and tetanus lose their toxicity when so exposed. Again, Professor Sidney Russ has remarked :

"If ultra-violet radiation be directed upon an infected wound, the result of an adequate exposure will be, that the pathogenic organism on the surface will be promptly killed. Cultural plates made, show that bacterial cultures of all types, upon radiation by ultra-violet light, were all immediately killed."

It was briefly mentioned above that blood platelets were increased after exposure to the rays. In considering this subject, it should be added that many authorities claim that after exposure to the rays an increase in the number of blood platelets is observed. It is known that infective conditions in which blood platelets are decreased are developed if an animal is starved of the fat soluble vitamin A. When the number of platelets is thus found to be diminished, ultra-violet radiation has been shown to bring about a restoration of the normal number.

Cramer and Drew[1] have found that animals kept in a dark room from birth show no obvious sign of ill-health, and apparently differ from those fed on the same diet and kept in well-lighted rooms only in the peculiarity that they have an abnormally small number of platelets in their blood. If these animals are exposed to radiation from a mercury vapour lamp, the blood platelets increase in number. The function of the blood platelets is at present unknown and their possible significance in rickets is obscure, but Cramer and Drew think that these structures represent a defensive mechanism against bacterial infection, and on this hypothesis it is easier to understand the beneficial action of light upon a disease such as tuberculosis.

The formation of an increase in red blood corpuscles at sea-level by the action of ultra-violet light is both claimed and denied.

Leucocytosis has already been mentioned, but one experiment, alluded to by Hill, must be quoted in connection with the therapeutic action of ultra-violet radiation on the blood. Arterial blood has been allowed to flow through a quartz tube (clotting having been prevented by an injection of hirudin) and exposed to the mercury vapour lamp for a few minutes. Both red and white corpuscles were increased, the red from 5,000,000 to 7,000,000 and the white from 10,000 to 30,000.[2]

There is one effect of, or action incident to,

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[1] *British Journal of Pathology*, October 1923.

[2] Naswitis cit. after "Strahlentherapie," 1923, No. 14, p. 917.

ultra-violet radiation which has yet to be logically explained, this is its analgesic quality. It would appear that the rays exert some biologic action in the vicinity of irradiated inter-epithelial nerve fibrils; for, given a constant ultra-violet intensity, a nerve sensitive area (such as pruritus) may be modified in two ways; that is, made either better or worse, or the condition may remain unchanged. It depends upon the exposure and other usual factors; but the exact manner in which pain is relieved is at present unknown.

Pain, too, in the deeper structures can be relieved by the ultra-violet rays. This may be due to the superficial hyperæmia produced, or it may be caused by attacking the peripheral nerve irritation of an area according to the view that there is a reflex relation between many areas of cutaneous, surface, and various internal organs. The pain referred to deeper structures, is relieved through this association. But in whatever way it is brought about, whatever may be the mechanism involved in affecting analgesia, it is an important therapeutic property of ultra-violet energy to allay pain, a property apparently but little known and less used.

To sum up the therapeutic changes brought about by ultra-violet rays, they are as follows:

> Objectively we have the *latent period*, then *hyperæmia*, after which *desquamation or peeling* of the skin, and lastly *pigmentation*.

Subjectively: locally, an analgesic effect is produced in painful areas, and, generally, a sense of buoyancy and well-being pervades the whole body.

In the laboratory have been demonstrated the various *blood changes*, such as increase of *calcium*, *phosphorus*, *iron*, *iodine*, *blood-platelets*, *bactericidal properties of the blood*, and an increase in the number of the *blood cells* themselves.

Lastly, in our present state of knowledge we can say a stimulation of the endocrine glands takes place, and that vitamins are rendered more active.

With further reference to the advantages of ultra-violet radiation over direct sunlight in this country, physicists have told us that in the main, the beneficent part of the solar spectrum is that known as the actinic ray, which comprises the near, far, and extreme ultra-violet, and it is to this ray that the pigmentation, the chemical and other changes in the blood, and so forth are attributable. Now, when a patient is exposed to direct sunlight it is true that he gets all these, but he gets more, he gets all the visible, and many of the depressing invisible, rays above the ultra-violet and down to and including the hot infra-red region. And not only does the patient get doses which are not prescribed, and these in quantities of varying and unknown proportion; but it is difficult, if not impossible, to give an accurate dose of the ultra-violet ray owing to cloud, moisture, smoke, dust, altitude, and so many varying factors.

With the artificial sunlight we are able to administer a mathematically calculated dose of a ray composed of exactly what we wish to prescribe. As I have pointed out in a previous chapter, if we wish to give one-eighth of a grain of morphine, do we collect a handful of poppy heads and make a decoction and tell the patient to take a mouthful or so of it ?

So, if we expose the patient to sunlight of variable quantity mixed with depressing and other rays which we have no wish to prescribe, this is reverting more to the old-fashioned shot-gun prescription, and is not worthy of the accurate prescribing of the present day. Therefore, if we wish for accuracy, in this country at any rate, it must be obtained artificially. Accurate actinotherapy can only be obtained from artificial sunlight.

It must be clearly understood that it is not heliotherapy that is attacked in any way, especially when administered away from London, and at altitudes where the factors already enumerated are less numerous. Rather are these remarks in defence of actino-therapy against attacks made on it by men who, I fear, have had little clinical experience of its modes and uses.

TECHNIQUE OF TREATMENT

CHAPTER V

TECHNIQUE OF TREATMENT

WITH every apparatus or instrument in the hands of the physician or surgeon, a thorough knowledge of its capabilities and a familiarity with its possibilities are needful, in order to ensure successful results. And this is perhaps especially true of ultra-violet radiation and of the different instruments used for its production. Those in most general use, as has been seen in Chapter III., as far as the practising physician is concerned, are :

1. Mercury vapour lamps in quartz, which may be either—
    (1) Air-cooled or
    (2) Water-cooled.
2. Carbon arc.
3. Tungsten arc.

The difference between the first two types of lamp merits attention. A starting-point will be found in a consideration of the fundamental physical principles that are involved. To begin with, we know that when electrical energy is transmitted through mercury vapour, ultra-violet energy is emitted from a central stream of light that is thus created. An evolution of heat accompanies this transformation, and volatilises the mercury. The result is, in an air-cooled lamp, that the ray is filtered through the mercury vapour mantle before it passes the quartz. In the water-cooled pattern, however, the mercury vapour mantle is quickly condensed. This process leaves the ultra-violet energy free to pass through the quartz, without being previously filtered through the mercury vapour.

Since the short ultra-violet wave lengths are not so penetrative as the longer ones, it follows that the air-cooled lamp furnishes a longer wave-length spectrum (near ultra-violet intensity). The spectrum for the water-cooled lamp, however, is relatively more rich in short wave lengths (far ultra-violet intensity).

Browning and Russ found that near ultra-violet intensity differs from far ultra-violet intensity in two ways:

> Near ultra-violet intensity (as from air-cooled lamp) has not much germicidal action, but it is more penetrative.
>
> Far ultra-violet intensity (as from water-cooled lamp) has marked germicidal action, but is less penetrative.

From this it will be seen that for systemic or general treatments by mercury vapour light, the air-cooled lamp is used, while for small areas and for local applications, the water-cooled lamp is indicated. The water-cooling allows closer proximity of the source of light to the portion of the body needing treatment.

Coming to technique in detail. Technique in ultra-violet radiation (and, indeed, in every other therapeutic measure) resolves itself into a question of reaction, and it has been said (by Turrell, I think) that the measure of the therapeutic effect is the amount of reaction induced. Now, the reaction is directly proportional to the intensity of the radiation, and as the intensity of the radiation varies with the amperage employed, it would seem a simple mathematical matter to define and limit the reaction by the amperage employed. But there are several other factors that have to be taken into consideration. It is difficult to lay down the exact dose, because each individual skin varies in its power of resistance to actinic light. Not only does one skin vary from another, but the skin of one individual will vary—the variation depending upon the situation of the area, and the amount of exposure to air and sunlight that it may have already received. An appreciation of these factors can only come with experience; but as one must have some ground upon which to base this, a table, which has worked well with me when using water-cooled lamps, is as follows:

DEFINITION

First Degree.—Slight reaction, practically no subjective symptoms, slight reddening of the skin, no visible exfoliation. Daily treatments can be given.

Second Degree.—Mild reaction as of slight sunburn, definite reddening, slight exfoliation. Daily or alternate days.

Both these, which may be classified as *stimulative erythemata*, are accompanied by a minimum of protoplasmic change with some capillary enlargement. It is bactericidal, and is an effect more sought after in the general body application of the rays.

Third Degree.—Intense reaction, as of severe sunburn; intense reddening; epidermis can be peeled off in large strips. Four or five days' intervals.

This may be termed a *regenerative erythema*, and is a hyperæmic reaction which stops just short of blistering. It is stimulating and bactericidal as is the stimulative erythema dose; but, in addition, the maximum capillary reaction furnishes a regenerative capacity to the exposed area. It is the most used and the most useful of the reactions, and among its many indications are various skin lesions, infected mucous membrane or glands, *e.g.* tonsils.

Fourth Degree.—Blister formation. Ten or more days' intervals.

This is classified as a *destructive erythema*. It begins with a temporary stimulating hyperæmia.

This gives way to the regenerative hyperæmia and goes on till it affects the protoplasm of the cells, and occasions exudation and ultimately blister formation, the exudate raising the superficially destroyed cellular layer.

But for the ultra-violet lamp, as has been said, other factors than amperage, time, and distance have to be taken into consideration, and as a matter of experience one knows that some of the difficulties in estimating the dosage may be overcome by standardising the lamp; for, as has been said, lamps vary very much in output. There are several ways of doing this, or at any rate of standardising sufficiently, so that one is able to determine the length of exposure necessary to give the various degrees of erythema needed for therapeutic use.

Take, to begin with, the water-cooled lamp. A simple practical method of standardising this is as follows:

Light the lamp and allow it to burn for five minutes. Then take a slip of paper and cut a small hole in it. Place this paper over part of the arm and place the arm against the window of the lamp so that an area of epidermis is, through the hole in the paper, exposed to the lamp window for ten seconds. Repeat this on another part of the arm for twenty seconds; and again in another place for thirty seconds; and continue until a fourth degree erythema has been produced. On the following day, notice the results and try the experiment with the lamp at a distance of 2½ inches. In this way the particular lamp is standardised and the exact exposure needed to give any desired degree of erythema is ascertained.

	CONTACT.	2½ INCHES.	8 INCHES.
First degree erythema	10 seconds.	1 minute.	2 minutes.
Second degree erythema	25 seconds.	2 minutes.	4 minutes.
Third degree erythema	40 seconds.	3 minutes.	6 minutes.
Fourth degree erythema	60 seconds.	4 minutes.	10 minutes.

There is no more valuable lesson in technique for the practitioner than to administer different erythema doses to his own skin. Such personal experience gives him confidence in himself and also enables him to lay down the law with firmness and successfully to answer cross-examination and to allay the fears of patients who are afraid of an overdose in such a way that convinces the patient that he is speaking as one having authority, and not as one gingerly handling a new measure.

There are patients who require larger doses. For instance, a patient of a well-marked dark type will need a 50 per cent. larger dose than a well-marked light type.

As has already been said, the exposure table given earlier in the chapter can serve only as a basis, or general average. Some patients will require more than the doses mentioned and others less. For instance, it may be taken as a general rule that the following classes of case will require a large dose :

Those with dark complexions.
Those who tan on exposure to the sun.
Congested skin areas.

On the other hand, patients who do not tolerate large doses are :

Fair people.
Those with blonde, or reddish hair.
Patients who ordinarily blister easily.
Normal skin areas.

In addition to the above factors which vary the dose, there is yet another, and that is age. As a rough rule it may be said that the dose for children is about half that for male adults; and for infants, half that of children. Sex, too, is another variant factor, and women's skins require a 25 per cent. less dose to produce the same effect as in the adult male.

Again, parts of the body, such as the face and hands, which are habitually exposed to the air, will tolerate large doses ; but on the abdomen and parts which are always covered, smaller doses will readily induce reaction.

To produce the desired effect, mucous membranes require more than the skin dose, and hollow metal applicators are used, the arc being about 4 inches from the mucous surface. One and a half minutes may be taken to be an average dose, say, for tonsillitis; but one minute, using compression with quartz applicators, will produce the same effect.

Another reason why it is impossible to lay down a hard-and-fast rule of technique for the dose of ultra-violet radiation lamps is that there is so wide a range both in quantity and in quality of rays generated in the apparatus of the various makers. Also the efficiency of a lamp varies inversely with the number of hours it has burned. A new burner is more efficient than one which has done 1000 hours of work, and the latter more efficient than one which has done 2000 hours. If the body of the burner become discoloured it is almost conclusive evidence that air has leaked into it and that oxidation has taken place. It must then be returned to the manufacturer.

So much for dosage of quartz lamps. In order to get the full effect of ultra-violet radiation upon the skin the latter must be free from all forms of greasy ointment, and if this has been applied it must be removed to allow the proper application of the ultra-violet ray. In like manner, the removal of scales, powder, and so forth is essential for the production of an accurate dose reaching the part under treatment. It need hardly be said, that as our object is to produce a reaction, it is futile to yield to any complaint on the part of the patient, and, when he experiences some burning sensation, to give remedies to soothe the same. Rather will a patient explanation of the effect that we are trying to produce appeal to his common sense; and not only will

he then cheerfully put up with the temporary but inconvenient irritation, but in his desire to get cured will "ask for more." Then he may be rewarded with a simple lotion or dusting powder, which will soothe the skin somewhat, and can be easily removed from it.

To get good results, it is highly important that the lamp should always be kept scrupulously clean. This is best secured by polishing it with a silk handkerchief or with gauze moistened with alcohol. The uncovered fingers should never be brought into contact with the lamp, because it reaches such a high temperature that if finger-prints be left on it when adjusting and the lamp then lighted, the prints will become etched into the quartz and lower the efficiency of the lamp by refracting the rays to all points inside the hood, and into the air, instead of allowing them to pass towards the surface treated. The easy way in which ultra-violet rays are refracted, must always be borne in mind.

In lighting a quartz lamp, it must be remembered that the lamp can only be operated on the direct or alternating current, and on the voltage for which it was made. As the current (D.C.) must flow through the lamp in one given direction, the contact plugs should be non-interchangeable. With the D.C. there should be a 15 ampère fuse in circuit, and a 20 ampère fuse with the alternating current.

When using the water-cooled lamp the following precautions should be observed. First of all see that the water is flowing. When the treatment is finished, stop the flow of water and then turn off the current. Do not let the water run away, but keep it in the lamp by means of the rubber tubing. This method will allow the lamp to cool gradually and will thus tend to prevent cracking, etc.

The method of lighting the air-cooled lamp is as follows:

When everything has been found in order, switch on the current and gently tilt the lamp forward so that the mercury is divided between the terminals. Then bring the lamp back to its original position. The mercury column is broken and the arc thereby struck. Before using, the lamp should be allowed to burn ten minutes, when the current consumption will be at its normal for therapeutic purposes. The difference between this and the starting consumption will be seen from the following table:

	VOLTS.	STARTING AMPERAGE.	AFTER 10 MINUTES.
Direct current lamp .	110	9	5
” ” .	220	4	2·7
Alternating current lamp	110	15	6
” ”	220	8	3·2

When ten minutes have elapsed the light may be applied to the patient. The operator must take care that he himself is protected. Conjunctivitis may be caused by a few seconds' direct exposure. This is extremely painful. Still, it is benign, and curable in a few days if the eyes are kept in the dark and the inflammation soothed with the instillation of castor oil. Very little protection is needed, but that little is of the utmost importance. Thin sheets of mica, glass, paper, wood, all absorb the ultra-violet rays and are opaque to them. As a ready means of protection most lamps are provided with a loose cap carrying a mica disc which covers the window.

In the treatment of deep-seated skin lesions, where it is essential that the maximum amount of rays should penetrate, recourse is had to firm compression with a quartz lens. This dehæmatises the surface layers of the lesion under treatment.

For giving treatment in small orifices, solid quartz rods are employed. These are mounted in a special holder which fits on to the lamp. The co-efficient of refraction of the quartz is so high that light is transmitted through it as through a tube, *i.e.* a greater quantity of the light reaches the patient through the quartz than through the air at the same distance. The Law of Light varying inversely as the square of the distance does not apply to transmission by quartz. This, however, is a digression, but a point important to remember.

These quartz rods are used in treating the ear, nose, urethra, and for localising the light on small nævi in children. The technique is to place the quartz rod in position, to hold the lamp in the right hand and the end of the rod between the finger and thumb of the left, and then to bring the lamp up to the rod and connect the two. This direction applies more to its use in the small orifices than in skin lesions. When treating prostates or internal piles a rectal speculum with obturator is used. On being introduced, the obturator is withdrawn and the lamp brought to the end of the speculum. For external piles there are special hæmorrhoid applicators made of quartz arranged in a holder which should be pressed firmly against the protruding mass. Care must be taken that the quartz block is firmly fixed in the holder, otherwise it may be drawn in by the sphincter muscles.

There is a special applicator for the tonsils which is very useful. The tongue being held down by the left hand, by means of a wooden tongue-depressor, the applicator already attached to the lamp slips over the wooden depressor until it touches the surface of the tonsil.

Other details of technique will be mentioned when dealing with the different diseases.

Air-cooled Lamp

It is of importance that the patient should be so placed that the rays strike perpendicularly the surface under radiation. This has been emphasised in Chapter II., where the compensatory time increments are given for the loss of light when delivered at angles less than 90°.

For small lesions, where a distance of 2½ inches is usual, the water-cooled lamp may be used. The facts of each individual case, however, will aid the decision. If the air-cooled lamp be used in treating large areas, the surrounding healthy skin should be protected. I generally use the black paper from used X-ray films with a hole cut in it. This may be fastened down by adhesive plaster, or plaster itself may be used to give a sharply defined margin. The following paste is suggested:

Tincture of green soap .	50 parts.
Water	50 ,,
Burnt umber . . .	15 ,,

Rub well in a mortar and apply with a small brush to the healthy tissue to be protected. After the treatment the paste may be readily washed off with water.

This paste has, however, failed me on occasion, and an erythema has been produced in the covered area. I presume some portion of the paste had dried, cracked, and fallen off. Adhesive plaster is a safer and surer protection.

When the protection, if needed, is in position, or in giving a general body treatment with the mercury vapour lamp, I usually begin treating chronic cases by exposing the abdomen at a distance of 20 inches from the tube for from two to three minutes. On the following day the back is exposed for a similar length of time, if the reaction has been equal to a first degree radiation, or more, or less, according to the degree of erythema obtained. On the third day the fronts of the thighs and legs are exposed; on the fourth their backs.

The eyes of the patient are protected by Crookes' glasses or smoked goggles, or by pieces of cardboard held on with a piece of veiling; or he is given a piece of cardboard to hold.

The more body surface that can be covered by the light, the greater is the therapeutic effect. Indeed, some American authorities say that every possible inch of the body should be rayed, even the soles of the feet.

At each successive exposure the lamp should be placed nearer the skin, say 1 inch, until a distance of 8 inches has been reached, and the time extended one minute on each succeeding occasion until a period of forty minutes has been attained. Exposures up to even longer periods have been made.

The technique described for the general body treatment is very much the same for all large areas which require to be treated with the air-cooled lamp.

The dose with the air-cooled lamp for the abdomen at 20 inches is two to three minutes. This exposure may be increased by one minute each treatment, or the initial exposure may be less, as has been stated. If the treatment be begun by exposure of the feet and legs, one may begin with seven minutes. For the hands, being a more exposed part of the body, one can give as much as eight minutes at 18 inches.

THE CARBON ARC

For general body treatment in this country the carbon arc is more generally preferred, even to sunlight itself, since the risk of over-radiation is less. Containing as it does a higher proportion of infra-red rays, it prevents the patient approaching, or at any rate remaining, too near to the lamp.

Carbon arcs give an artificial sunbath of great value, affording much ultra-violet radiation, and like the sun, they have a continuous spectrum.

The general body treatment with these baths, super-added to local radiation, increases the effect of the latter to a remarkable degree, often making a 50 per cent. difference. That is to say, where good results are noticed in 50 per cent. of cases getting local radiation only, this number may well be 75 per cent. when the general body bath be added. This local effect is due probably to the power of these baths to alter the chemistry of the blood and increase its immunising and bactericidal properties. The general effect upon the patient by these baths is almost immediate, the patient experiencing a sense of well-being often after his first bath, and certainly not later than the second or third exposure.

Lamps having arcs drawing 25 ampères are sufficient, and two can be placed side by side with the patient lying parallel to them at a distance of from 2 to 4 feet. Two, three, or four such lamps connected in series can be placed on either side of the patient, who can lie parallel to them or be seated on a stool. It must be remembered that the angle at which the rays strike the patient is of importance, and the time factor must vary with the angle of incidence. (*See* p. 24, Fig. 3.)

If, however, it be wished to treat four or five patients at a time (as is the practice at Alton and at the London Hospital), a 75 ampère arc is used. In any case the patients are nude save for a loin cloth and an eye shade, and where several are treated at a time, they sit round in a circle at a distance of about 40 or more inches. The duration of this bath should be ten minutes, increasing by a daily increment of three minutes until a period of two hours may be enjoyed with benefit.

In using the carbon arc lamp for the treatment of one patient only, a lamp capable of carrying 25 ampères is sufficient, if time be no object. Two of these lamps can be placed side by side. Better still is a bank of two, three, or four placed on either side or back *and* front of the patient.

With such an arrangement two patients can readily be treated at the same time. The dosage of this, perhaps the most valuable form of Artificial Sunlight, varies, of course, with the amperage of the arc and the distance from it to the patient. With the bank of three arcs of 20 ampères each on either side of the patient, and a skin-arc distance of 24 inches, an exposure of fifteen minutes is a safe dose with which to begin. With children, or women, especially those with a fair skin, ten to twelve minutes may err on the safe side, but will avoid recrimination the next day. A certain light sunburn should be produced so that there is a slight feeling of soreness when the next bath is taken or the body rubbed with a towel. The face or neck during these exposures may be thickly powdered with ordinary toilet powder if the sunburn effect is to be avoided in these areas. Should the skin feel irritable after the exposure to the carbon arcs, and it may well do so if the full therapeutic dose be given, some soothing lotion of the glycerine and cucumber variety will afford great relief. It is wise to warn the patient that this irritation may happen and to give a prescription for a lotion lest it come unawares on the patient, and he or she may telephone to the doctor in the middle of the night imputing blame to him and to the sunlight. The irritation will usually have subsided at the end of the second or third day, when another exposure should be given, the time of which should be increased from one to five minutes according to the amount of reaction experienced. Further exposures should be given at similar intervals, the time of which, increased in the same ratio with a maximum time limit of thirty to forty minutes. Some patients will do well with applications every other day, but I find for the majority of people one treatment twice a week produces the best results. For how long this should be continued it is difficult to say, the effect produced varies so much with different individuals. Of course when the exposure forms part of a combination of local and general treatment for a specific lesion its continuance will depend upon the lesion involved, and, as has been said, an exposure may be extended up to two hours. But when taken as a general reconstituent tonic or as a therapeutic measure to aid convalescence after an illness, a period of from four to six weeks is to be recommended. As a general winter pick-me-up there is no reason why one or two treatments a week of half an hour each should not be continued throughout the whole of our sunless weather.

One other point should be emphasised, and that is the room in which the general body bath is being given should not be allowed to become too warm. The good results obtained in Alpine mountain resorts where the body is exposed to the solar ultra-violet rays and cold may well be due not only to the light but also to the cold, for exposure of the naked body to cool air raises the basal metabolism. Therefore it is as well to open a window during the administration of the body bath. If this be done after the patient is feeling the warmth from the arcs it will be welcomed as a refreshing adjuvant to the treatment.

Another small point which makes for the comfort of the patient is the placing of a hot-water bottle at his feet as he takes his place, before even the light is started, and at the same time the patient should be given a pair of dark goggles, and in the case of women a pair of bathing drawers or loin cloth.

It may be a matter of interest to give some

general idea of the dosage for exposure to sunlight such as is obtainable at Leysin, for it has occurred in my experience that an ardent sun-worshipper who was in the habit of taking a bi-weekly dose of artificial sunlight in London suffered from the ill-effects of an overdose of the January morning sun in the south of France. Gauvain gives the dosage as follows :

First Day.—Expose legs to knees for five minutes hourly, for three successive hours.

Second Day.—Expose legs to knees for ten minutes hourly, for three successive hours.

Third Day.—Expose legs to groins for ten minutes hourly, for three successive hours.

Fourth Day.—Expose legs and buttocks for twenty minutes hourly, for three successive hours.

Fifth Day.—In addition, one aspect of the trunk for five minutes.

Eighth Day.—Total exposure for twenty minutes hourly, for three successive hours.

The last form of ultra-violet radiation to be dealt with in this chapter is that derived from the tungsten arc. The technique is as follows :

With direct current capable of giving 15 ampères at 100 volts, the part that is to be exposed should be placed 12 inches from the arc, and the light focused by the reflector, or lens, or both. With regard to the reflector, the material of its construction is of importance. Silicon is the most efficient for the purpose, as it reflects 75 per cent. of the rays, while silver reflects only 6 per cent. The lens is a 2-inch quartz lens, having a focus of about 4 inches, and is held in a frame on a handle. This frame should be sufficiently large to protect the untreated areas from the action of the light. (*See* Fig. 8, p. 46.)

The method of treatment is simple. The apparatus having been tested and found to be in good order, and spectacles being adjusted, the part to be treated is placed in position. The current is then switched on. The ammeter should register 10 ampères. The rays are focused on the affected area for five minutes. This will usually produce the erythema dose which is our object. The application of the light should be repeated when the erythema is fading away, and it will be found that applications will be needed every three or four days.

Treatment varies from five to ten minutes; parts of the body ordinarily exposed to the sun, especially the head, requiring the longer time. At the end of the treatment there is a slight erythema, and this in a few hours is followed by a more intense secondary erythema. The application should be repeated when this has faded, usually in four or five days. Repeated applications produce a bronzing similar to sunburn, but this only persists for a short time.

During the late war, this light was used in the treatment of wounds which had become sluggish and would not heal. In most cases after a few treatments the surrounding swelling and œdema subsided, discharge was lessened, and new granulations and epithelium commenced to be formed.

This agent has been proved to be of no less value in civil practice, and successful results have been obtained in several classes of case. Of these, perhaps, the most gratifying is the treatment of alopecia, either localised as in alopecia areata, or in cases of general loss of the hair, as in premature baldness in young men.

Applications are given to the affected areas or to the whole scalp, and it is most essential that a brisk reaction, as shown by the erythema, be obtained. Each area should receive about two doses per week, and the course should last from four to eight weeks, according to the severity of the case. Soon after commencing treatment the scalp looks more healthy, the shininess disappears and fine downy hairs commence to grow. These in their turn fall and are replaced by hair normal in texture and colour.

Overdose may be either local or general. A local overdose to the skin means producing a higher degree of erythema than was intended—that is, causing a destructive erythema instead of a regenerative erythema, or a regenerative when only a stimulative erythema was intended. There is nothing special to be noted in the treatment of these conditions. Soothing lotions for the milder cases, oil or oil and lime-water for the fourth degree erythema; and, as already noted, an application of the high candle-power incandescent lamp is also of service.

Another condition which may come under the head of local overdose is acute conjunctivitis. This is usually due to carelessness, and the appropriate treatment has already been indicated (p. 91). It is easily avoided, but the patient should be warned of the possibility of its occurrence and the means of its prevention be indicated.

An overdose of the general body treatment is rarely seen in a period less than two or three months, and then only when the exposures have been repeated three or four times a week, and have had a duration of over half an hour. The onset is gradual, and the symptoms those of overstimulation of the nervous system. The patient will become irritable, though usually with a sense of buoyancy. There may be loss of appetite and lack of energy. There is difficulty in getting the usual amount of sleep, the patient finding it hard to get off to sleep because ideas are flowing too rapidly, or upon awakening thoughts so occupy the mind that the relaxation which is essential to healthy sleep is well-nigh impossible.

The overdose from this general irradiation may be either from one single exposure of too long a duration, or from many exposures continued over too long a period. The symptoms of the former vary from a sensation of malaise and a general tired feeling to headache, more or less severe, and I have seen slight syncopal attacks. All these are quite transient and need no treatment other than rest and quiet.

Cessation from exposure to the ultra-violet rays causes all the symptoms to disappear.

There seem to be no permanent ill-effects, and the discomforts appear to be but temporary.

One case of over-exposure was quoted in *The British Medical Journal*, April 11, 1925, by Drs. Henry MacCormac and Moreland McCrea, which shows that over-exposure may be followed by undesirable, even serious, results. The patient was an unusually healthy man, aged seventy-two, who was accustomed to expose himself to ultra-violet radiation from a lamp placed above his bed for about ten minutes daily. On one occasion he happened to fall asleep while thus exposed, with the consequence that the lamp continued to play over him for one hour and ten minutes. The immediate effect was a severe burning of the skin, the front of the body becoming first bright red and swollen, and subsequently desquamating. Seven days later both legs were swollen up, and in places there were raw areas exposing the papillæ. Twelve days from the initial exposure a general erythema of the trunk and extremities was noted, with urticaria, and the patient much disturbed by the severity of the itching, which interfered seriously with rest and sleep. Three days later there was an extension of the eruption to the face, which became puffy and wept in places. Seventeen days from the original exposure a definite change occurred, possibly as a result of the absorption of toxic substances from the skin. There was restlessness, disturbance, and little sleep; the cardiac rhythm became disordered with the development of extra-systoles. The patient continued to be gravely ill for four days, then rallied and gradually recovered, convalescence being uninterrupted and normal health regained.

As Drs. MacCormac and McCrea say, the mishap may serve as a warning against the irregular use of the special method of treatment. It serves to point out how ultra-violet therapy should not be used by all and sundry, but administered only under proper medical supervision.

ARTIFICIAL SUNLIGHT IN SKIN DISEASES

CHAPTER VI

ARTIFICIAL SUNLIGHT IN SKIN DISEASES

ULTRA-VIOLET rays have hitherto been used more frequently in dermatological conditions than in any other class of disease. Among these, pride of place must be given to the treatment of lupus, which was begun by Finsen (the creator of artificial light treatment) in Copenhagen, and in this country by Sequeira.

It is true that at first Finsen used the sun as a source of light, but soon found that if there were to be any continuity in the treatment, it would be necessary to use artificial light. He chose as source the carbon arc, as this, in its properties and composition, comes nearest to the light of the sun, since it has an almost continuous spectrum. Later, Finsen used the carbon arc light in preference to the sun itself, because he found that it contained more ultra-violet rays than did sunlight, in which so many of the ultra-violet rays are absorbed by the atmosphere.

Probably more cases of lupus have been treated by ultra-violet radiation than all other skin diseases together, yet there is a great variety of the latter in which these rays can be profitably employed, and the reason of this may be seen in a sentence of Crocker,[1] in which he states that the keynote of modern dermo-therapeutics is antisepticism, and, as every surface which is bathed in ultra-violet radiation is rendered aseptic, one reason for its efficacy in a great variety of skin diseases is made plain.

Perhaps it might be more usual and scientific to classify these either in order of their importance or according to their development, but, for one who lays no claims to be a dermatologist, it will be more expedient to enumerate them in alphabetical order.

ACNE : *Vulgaris, Rosacea, Keloid*

This subject is one which has for many years interested dermatologists and doctors before the days of dermatology as a speciality, and few skin diseases have been attacked by so many methods as has acne. But it will be noted that the aim of most of the local treatments has been the production of a hyperæmia, and never before has there been a more safe and satisfactory method of producing a hyperæmic condition than by the use of ultra-violet rays.

Obstinate cases of acne, whether on the face, or the neck, or the back, especially in those patients who have a pale and oily skin, lend themselves readily to treatment by ultra-violet radiation. Although I know that the X-ray is the court of last resort, it is not always possible to appeal to it. For one thing, it is essential that

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[1] *Diseases of the Skin*, Radcliffe Crocker (1913 edition).

the physician should be a skilled radiotherapist to apply X-rays to the face. In the case of ultra-violet rays there is no such handicap, for nothing but negligence on the part of the physician can cause any permanent damage to the cutaneous surface treated by the light. To bring about permanent relief, the usual remedial agents, both internal and external, should not be neglected; otherwise a recurrence of the trouble is almost inevitable.

It is needless to remind the practitioner that in addition to the local condition, primarily due to bacillary infection, there is often also some general condition, anæmia, constipation, poor circulation, or a general lack of tone, which must receive attention; and it often happens that for this the general body treatment with the carbon arc is of great service. The difficulty I have found is in persuading patients to submit to a dermatitis of the face, which may last for three or four days after each exposure. When once this reluctance is overcome progress is rapid. The skin peels off, and the acne will be found to be greatly improved. After the reaction has cleared up the treatment should be repeated.

Acne rosacea.—If the disease be yet of the hyperæmic type, mild radiations, *i.e.* second degree erythema, with the lamp at 2½ inches, will suffice. But for the hypertrophic and telangiectatic conditions it is necessary to produce a third degree erythema, with contact under firm pressure with clear quartz window or suitable quartz lens. When exfoliation has taken place the treatment should be repeated, and so on as often as necessary. The efficiency of this method in removing the superficial disfiguration, and the total lack of scarring, render it a very valuable form of treatment.

Acne keloid.—Here, on account of the heavy thickening of the tissues, compression with the quartz lens is essential, and only one exposure at each sitting can be administered. In all keloidal conditions X-ray results have been so brilliant that it is doubtful, where it is possible for the patient to have the advantage of this agent, if it should not be used in preference to ultra-violet radiation.

ALOPECIA, ESPECIALLY ALOPECIA AREATA

General alopecia differs in the male from that in the female, not only in character but in the fact that it is more difficult, probably owing to the nature of its distribution in the female, to get results with ultra-violet radiation. In the male there is a progressive loss of hair commencing at the crown and the frontal region, which goes on to a complete baldness on the top of the head. This is easily accessible to the light, whereas in the woman there is more a general thinning of the hair, and each hair casts a shadow, which prevents the light from reaching the scalp and causing that hyperæmia which it is necessary to produce. With the hyperæmia the nutrition of the scalp is improved, and whatever the cause of the baldness may be, it connotes some disturbance of the nutrition of the scalp. It cannot be said that the treatment of alopecia of the ordinary type by ultra-violet radiation has been attended by very brilliant results, but I have had many cases showing definite improvement, especially in the premature alopecia of men, and when it was not hereditary. Undoubtedly ultra-violet radiation has an action, by producing hyperæmia of the scalp, in stimulating the growth of the hair. It is a matter of considerable difficulty to know how to advise a patient when he asks whether or not he shall continue the treatment; but I take as a guide the daily loss. To estimate this, the patient is instructed to brush the hair for five minutes with a perfectly clean brush for three nights in succession, and bring the " combings " in three separate envelopes. The average of these three is to be reckoned as a daily loss. This is compared with the daily loss reckoned, say ten days later. It should be noted, too, how many hairs were long and how many were short. It is the patient whose daily loss does not decrease, and who is losing many short hairs, whose condition does not warrant a good prognosis.

Either the air-cooled lamp or the Krohmeyer may be used, whichever is the more suitable for the size of the denuded area. Each treatment should be of sufficient duration to produce a definite first degree plus erythema. When treating the female scalp, a certain part, or furrow, should be selected for treatment, and the hair brushed away from this on either side.

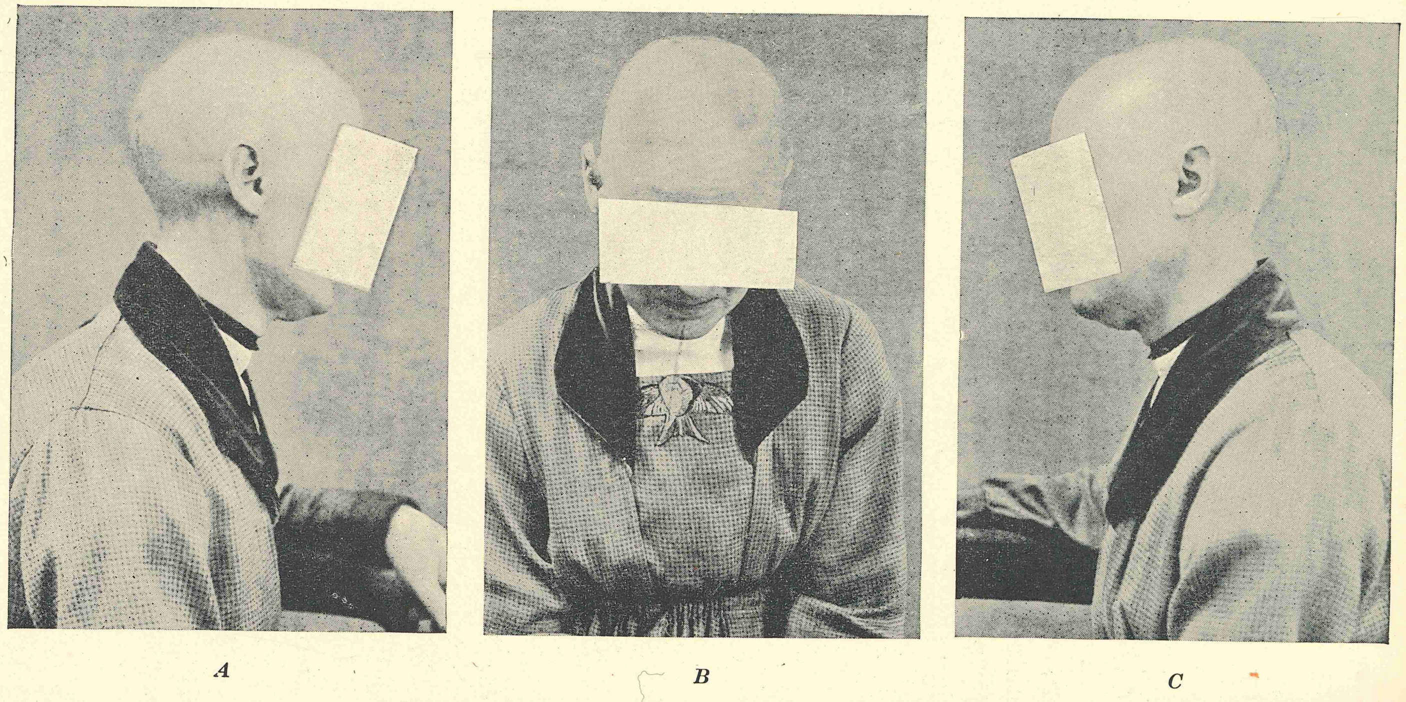

FIG. 14.—CASE OF ALOPECIA AREATA BEFORE TREATMENT.
(From Turrell's *Principles of Electrotherapy and their Practical Application.*)

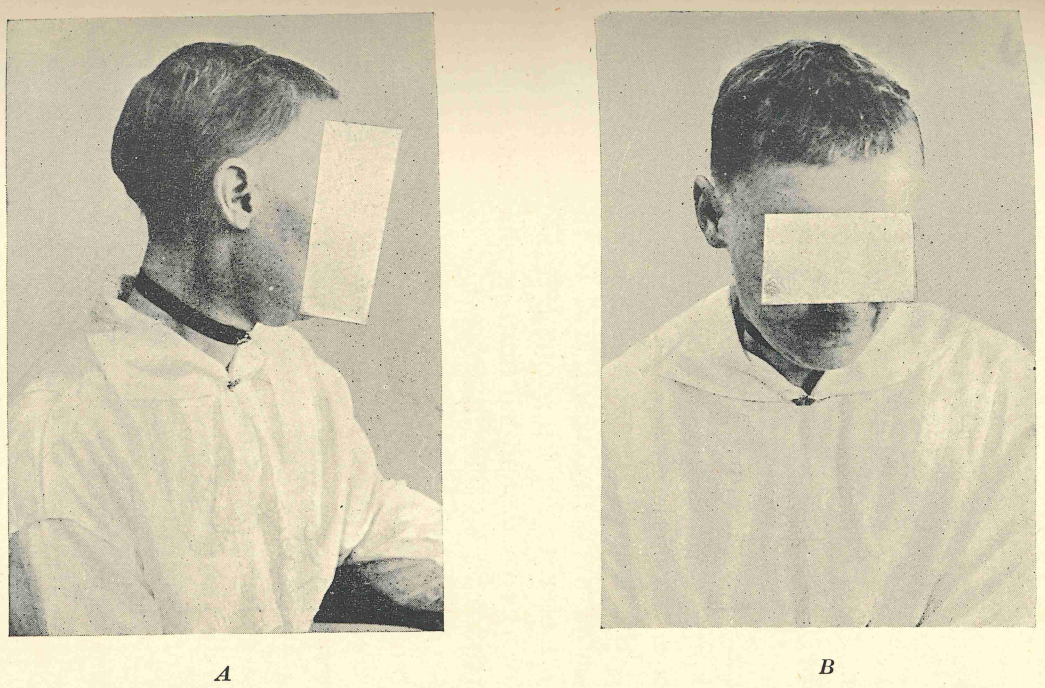

FIG. 15.—CASE OF ALOPECIA AREATA (SAME PATIENT AS FIG. 14) AFTER THREE MONTHS' TREATMENT BY ULTRA-VIOLET RADIATION FROM THE TUNGSTEN ARC.
(From Turrell's *Principles of Electrotherapy and their Practical Application.*)

In the treatment of alopecia areata a much more favourable prognosis may be given, especially in those cases of recent development where no extensive atrophy of the follicles has occurred. Various sources of ultra-violet rays have been used in this disease. Krohmeyer himself used an iron arc, 15 to 25 ampères, at a distance of 4–10 cms., from half a minute to ten minutes to each area. Turrell uses the tungsten arc, 15 ampères, 12 inches for five minutes. One case of his which I had the pleasure of seeing with him is so striking that I reproduce the figures illustrating it from his book.

In the United States, the Krohmeyer lamp is almost universally used, and is the method I have latterly adopted; but I think success will follow the treatment no matter what the source of light may be, *provided the hyperœmia induced is sufficiently intense.* The lamp is placed in contact with the bald patch for a time, sufficient to produce a second degree plus erythema. The interval between treatments must be long enough to allow for the subsidence of whatever reaction follows the application of the rays.

In all these treatments for alopecia, any other part of the skin of the patient on which the light falls—ears, forehead, face, or arms—must be carefully protected. It will be found to be sufficient if these areas be covered with pieces of paper or cloth.

Ultra-violet radiation in the treatment of alopecia areata is little short of revolutionary, and holds out a hope to many cases for the regeneration of hair which has been hitherto considered hopelessly and permanently lost.

Boils, Furunculosis, Carbuncles

The pathology and treatment of these three conditions being so closely allied, they may be taken together. Each of them is invariably an expression of not only local, but general lowered resistance. This provides the key to treatment. The local lowered resistance has allowed the staphylococci to grow and multiply, and this should be treated locally with the bactericidal short rays of the water-cooled lamp, and the lowered tone of the general system be raised by the general irradiation of the whole body. Locally, a third degree erythema should be produced with the lamp in contact, not only with the actual area occupied by the boil, furuncle, or carbuncle, but with an area of about an inch of the skin surrounding it. If the area be too large for the Krohmeyer lamp, then the erythema may be produced with the air-cooled lamp at a distance of 8 inches. One such treatment before the formation of pus will usually be sufficient to abort the pathological process. It would perhaps be a logical proceeding to remove all covering from the surrounding skin half-way through the treatment so that other infected follicles may be sterilised. If the tissues have already broken down and pus have formed, there is no reason to depart from the ordinary rule of free incision. Subsequent to this, an exposure to ultra-violet radiation will hasten resolution and shorten the period of recovery. Sampson is very strong on preceding the ultra-violet radiation with a pastille dose of X-rays, with 5 to 6-inch spark gap and filtered though 1 mm. of aluminium. He has also found in every case but one of carbuncle which failed to respond to this treatment, that the patient was a diabetic, who while showing no sugar in his urine, gave evidence from a blood test of a sugar content higher than normal. It may be said that whenever a normal dose of ultra-violet radiation produces an excessive general reaction the presence of sugar should be suspected and an examination made of the blood.

Dermatitis Venenata

This includes the various inflammations set up by numerous external irritations of animal or vegetable origin. Recently in this country cases due apparently to dyed fur were noted. In California and other parts of the United States a well-known cause is the poison ivy or poison oak (*Rhus venenata*, or *Rhus toxicodendron*). The intense burning and stinging are usually controlled during the first two or three exposures, which check the spread of the infection and reduce the duration of the disease. A second degree erythema should be produced, using the air-cooled quartz lamp at a distance of 8 inches. Treatment should be given daily until the condition is cured.

Eczema, Acute and Chronic

This constitutes about one quarter of all skin diseases, either complicating the clinical picture of other dermatological conditions or appearing of itself in its many protean manifestations. So varied are these that it is impossible to lay down the treatment by ultra-violet radiation with any degree of precision. But speaking in broad generalities the dry scaly forms should be treated by the water-cooled lamp in contact with the skin, producing a third degree erythema, while for the acute weeping types more sedative rays from the air-cooled lamp, or the carbon arc, should be used at a long distance. Eczema vesiculosum also, as a rule, yields readily to the ultra-violet rays.

Herpes: *Zoster*, *Facialis*, *Labialis*, *Progenitalis*, or *Præputialis*

Although these varieties are considered by many dermatologists to be distinct entities, they receive equal benefit from ultra-violet radiation.

Until quite recently herpes was considered a disease which obstinately resisted treatment, and often the best that could be done in severe cases was to give a hypodermic injection of morphine to relieve the pain. Now much assistance can be given to the patient in all forms of herpes, and relief afforded, not only from the severity of the eruption, but from the accompanying neuralgic pains. *The earlier the ultra-violet light can be administered the more marked is the benefit derived* *from it.* Radiation will often arrest the development of the vesicles, and they will dry up and leave little or no scarring. Even when the eruption affects the ophthalmic division of the fifth nerve, where scarring, and severe scarring, is the rule, the duration of the disease is greatly lessened by the application of ultra-violet radiation. If the case be seen early enough, the water-cooled lamp should be applied to each vesicle in turn with the quartz applicator, and a third degree erythema produced. When this begins to fade the application should be repeated. If the patient be not seen within twenty-four hours of the appearance of the eruption, and only when the latter has covered a large area, the air-cooled lamp is used over the whole of the affected part and a second plus or third degree erythema induced.

IMPETIGO

The short bactericidal rays from the Krohmeyer lamp are indicated in impetigo, and a third degree erythema should be produced. If necessary, when the erythema subsides treatment should be repeated, and it must be remembered that ultra-violet rays will not penetrate the scabs or crusts which cover the lesion. Before applying the ultra-violet light every trace of crust and every overhanging blister-margin must be removed. The best and most simple way of doing this is by prolonged and frequent bathing or dabbing with cotton-wool soaked in hot water.

The patient is instructed to mop off the crusts by bathing the affected part half an hour two or three times daily. At the time of treatment all crusts must be carefully wiped off with wool or picked off gently with a pair of forceps. When this is done, and not before, the ultra-violet light is applied.

LICHEN PLANUS

It is a fortunate circumstance that the variety (or varieties) of lichen in which X-rays only aggravate the disorder is (or are) amenable to ultra-violet radiation. It is useless in lichen planus verrucosus, especially on the heaped-up patches on the lower part of the leg, the burning and itching of which usually yield to X-ray therapy. But in the widespread irritable eruptions of lichen planus, in its acute form, ultra-violet radiation will often control the irritation and be of the greatest service. The air-cooled lamp is used, the distance varying with the area affected. A second degree erythema should be produced and repeated when it has faded away.

LEISHMAN'S SORE

I have only had the opportunity of treating two cases with ultra-violet radiation, and up to the time that this agent was employed no remedy seemed to have any effect; but when this was used improvement was soon manifest. The last case was referred to me by Mr. William Turner. The sore was in the left groin and was practically an equilateral triangle, each side 7 inches long. Sixteen weeks after beginning the treatment the entire surface was healed over, with the exception of two small holes at each end of the scar.

LUPUS

This is a fairly common disease in this country, being estimated at 2 per cent. of all the skin cases seeking relief at the various skin hospitals and dermatological departments of hospitals. In its treatment the utility of ultra-violet radiation, as introduced by Finsen, is beyond the realm of controversy and rests an accepted and established fact. Dr. Sequeira's monumental work at the London Hospital is too well known to need any mention here. For nearly a quarter of a century he has been using ultra-violet radiation patiently and persistently, and testifies with characteristic scientific reserve that the results "continue to be of a highly satisfactory character." Reference should be made to the various communications of Dr. Sequeira.[1]

Of the treatment of lupus by ultra-violet radiation but two points should be mentioned here. One is, as was seen in lichen planus, that the form which was suitable for ultra-violet radiation was unsuitable for X-rays; so, too, there are two forms of lupus, of which one is

curable by ultra-violet radiation, and contra-indicated for treatment by X-rays radiation. It is the dry type in which there are the characteristic yellowish nodules, which is amenable to ultra-violet rays, and provided the area be not too large the effects of this agent are excellent. *But X-rays in this type are absolutely contra-indicated owing to the grave risk of carcinoma supervening.* As this is not a treatise on X-rays, the reason for this need not be here discussed. It is only mentioned as being an instance of the different effects of rays derived from two parts of the spectrum.

In the ulcerative type of lupus and in scrofuloderma, X-rays are of great utility, and with mild antiseptic treatment and careful cleansing the ulcers rapidly improve. When this has taken place ultra-violet radiation should be employed.

The other point to be mentioned in connection with ultra-violet light and its use in lupus is this. When the nude body and limbs are exposed to ultra-violet radiation in addition to the local application, the percentage of cures is considerably higher, and many cases which have failed to respond to local treatment immediately show improvement when the general body bath is added. At the Portsmouth Meeting of the British Medical Association, 1923, Professor Reyn claimed that the percentage of cures can be increased from 60 per cent. to 90 per cent. by a combination of the local application of ultra-violet rays and the exposure of the whole body to the carbon arc light. Dr. Sequeira at the same meeting confirmed Professor Reyn's figures, and testified that the facts were in no way overstated. At Bradford, in July of last year, at the Annual Meeting of the British Medical Association, Dr. Sequiera gave as his experience of the use of the body light bath, that it produces :

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[1] "Seven Years' Experience of the Finsen Treatment," *The Lancet*, March 7, 1908; "The Finsen Light Treatment at the London Hospital, 1903–13," *The Lancet*, June 14, 1913; "Treatment of Cutaneous Tuberculosis," *The British Medical Journal*, September 22, 1923.

"1. Erythema in the irradiated area. This is usually transitory, and may be followed by desquamation.

"2. Pigmentation. The degree varies with duration and number of exposures, and with the individual. The source of light also has an influence. The carbon arc causes a deep brown, while the mercury vapour lamp produces a greyish-brown tint. This, no doubt, depends upon the greater penetration of the rays of the carbon arc.

"3. A moderate increase in the body weight observed in some cases.

"4. A slight increase in the leucocytes was noticed in a few of the patients.

"5. An increase in the bactericidal action of the blood ; but in some instances there is no change, and it seems probable that this observation may have a prognostic significance (Colebrook).

"6. Steady improvement and actual healing, without local treatment, of surgical tuberculosis and especially of lupus vulgaris, both of the skin and mucous membranes. In lupus the combination of local light treatment (Finsen therapy) with the light bath gives 90 per cent. of cures.

"7. A marked improvement in the general health of the patients."

It has often been said that there is no royal road to success in the treatment of lupus. But it would seem that ultra-violet rays are lighting up a road which, if it be not a royal road of success, may well be an avenue leading to it.

Nævus

This is a condition which responds extremely well to ultra-violet rays, and the cosmetic results obtained are superior to methods hitherto in vogue. There is no scarring, and, after the reaction subsides, the skin retains its normal texture. The scarring, which may have been previously produced by caustic agents, will often be improved by ultra-violet rays. Another advantage, especially to babies and young children, is that the application of the light is painless. In fact, nothing is felt except a slight warmth, or occasionally a slight pricking sensation. The Krohmeyer lamp is used with the window or quartz lens pressed firmly against the nævus. The surrounding skin should be protected with paper or adhesive plaster. The exposure depends upon the nature and age of the case, and on the strength of the lamp at the time of use. Severe reaction is necessary, *i.e.* a fourth degree erythema with blister formation. This renders the area tender, but not painful, especially when the blistered area is small. The treatment should be repeated when reaction has entirely subsided. When a full reaction has been obtained, one month should elapse before a repetition of the exposure.

ONYCHIA

Several diseases of the nails have yielded to ultra-violet radiation. In one case of two years' standing, the nails and nail-beds of the hands and feet were affected. A cure was reached after seventeen treatments with the air-cooled lamp, 10 inches for ten minutes, gradually increasing in time to twenty minutes each treatment. Another was a chronic inflammatory condition of the nail-beds of both hands. It had not the appearance of either tinea favosa or trichophytina. The lesion gave rise to no irritation, but was painful on pressure. The patient said that six weeks before coming to me the nail of the forefinger of the left hand began to fester, and the others soon followed suit. Seven treatments were given, consisting of similar doses to those given to the first case, and the patient was discharged cured. The third case was that of a dental surgeon. The skin, all round the nails of the first and second fingers and the thumb

of the right hand, was broken, cracked, and intensely painful. From the distribution, we came to the conclusion that the disease was due to the cocaine or its derivatives which he was in the habit of using in the course of his professional duties. When I first saw him he was considering giving up work. Four or five treatments completely restored him to normal. A few months later he had a recurrence, which again proved very amenable to ultra-violet radiation.

PERNIO

A chilblain is essentially an erythema occurring in patients with poor peripheral circulation and a disturbed vasomotor tone. The good results from the use of ultra-violet rays in this disease are probably due to their direct effect on the peripheral vessels and blood stream. The rays are not only of value in curing the lesion, but if used sufficiently early in those who have had previous attacks, they may prevent a recurrence. The same may be said of the treatment by the melted paraffin-wax bath, which I have been using for the treatment of chilblains since 1918. Occasionally I have found a case more prolonged in its course or more rebellious to the treatment than usual. Then I added to the melted paraffin-wax bath ultra-violet radiation, when the chilblains cleared up, however severe, persistent, and obstinate they had been before. Now the melted paraffin-wax bath produces an erythema which persists for several hours, so it would appear that the ultra-violet ray affects the chilblains in some other way over and above the erythema effects, and I think that, remembering that ultra-violet radiation raises the calcium content in the blood, and the excellent clinical results obtained by Luff in 1908 by the administration of calcium lactate [1] to patients suffering from chilblains, it can be understood why these should improve under ultra-violet treatment. A second degree plus or a third degree minus erythema should be produced, with the lamp at a short distance, say 3 to 4 inches. I say, the lamp, for, with equally good effects, I have used all kinds, the tungsten arc, the water-cooled and the air-cooled mercury vapour lamps, as well as radiation from the carbon arc. Many patients prefer this last form of ultra-violet rays, on account of the pleasant warmth which they experience when under its influence.

The result is surprisingly good, the irritation is rapidly calmed, desquamation frequently follows, and the fingers or toes resume their normal appearance.

The severity of the conditions does not appear to affect the result. Cases have varied from a condition of slight blotchy redness with irritation, to those in which there have been deep, raw cracks and fissures in the front of the fingers, and ulceration on the back of the hands. Naturally, the more severe the case the longer the time needed to attain a return to the normal;

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[1] *British Medical Journal*, January 20, 1909.

but improvement will begin with the treatment, and applications of the rays spread over a period of from two or three weeks will usually be found to be sufficient.

Pityriasis

The ordinary class of pityriasis in which ultra-violet radiation is most successful is the pityriasis capitis or pityriasis simplex, which is recognised as a general scurfiness of the scalp. Unfortunately there are two different and distinct types of this condition, and the differentiation between the two is not always easy; but it is important, indeed essential, from the ultra-violet light point of view. The more common form is generally due to bacterial infection (the bottle bacillus being the offending agent, I believe). This is the condition which yields readily to ultra-violet radiation. The other class of pityriasis is due to a deficiency in the normal oil. Here ultra-violet radiation fails. This type may be recognised in patients whose skin is generally dry and whose hair is dry and brittle. However, in the former case, a hyperæmia of the scalp is induced. It is quite impossible to speak with any accuracy as to dose, since in addition to the usual complicating factors we have more or less hair with which to deal. The hyperæmia should be sufficiently intense to last about five days, but not enough to produce any pain.

In pityriasis rubra with the erythema dose (third degree at 2½ inches, water-cooled lamp), the pale red spots turn an ivory white, then desquamation occurs, and when the normal colour has returned there is no more trouble. Repetition of the dose is rarely needed. Ultra-violet radiation of pityriasis rubra is almost specific in its action.

PSORIASIS

Considering the obstinate nature and the chronic and recurrent course of this disease, its depressing effect on the patient can be readily understood. In comparison with disagreeable applications he will welcome a remedy both painless and clean, especially one that will not interfere with his occupation and is free from remote ill effects.

The type of psoriasis which yields the better results is when the disease affects the classical situations, elbows and knees, and is of the more localised and infiltrated type, rather than the superficial and widespread class of psoriasis.

It is very reasonable to expect improvement in cases of psoriasis when treated with the ultra-violet light, for the comparative immunity of the exposed parts is probably due to the action of light normally occurring on them.

The preparation of the patient with psoriasis has much to do with the successful treatment of it. All traces of ointments, layers of powder, scales, etc., must be removed before the application of the light. A third degree reaction is needed. The lamp chosen will depend upon the

extent of the lesion. The water-cooled lamp at $2\frac{1}{2}$ inches gives perhaps the best results. For the subsequent irritation, a simple dusting powder, without any greasy application, will help to prevent pain or discomfort from friction of the clothes.

Very bad and chronic cases such as are not seen in private practice may need a small X-ray dose added to the ultra-violet radiation. In private practice the general body ultra-violet bath seems to quicken the cure and reduce the chance of recurrence.

PRURITUS ANI ET VULVÆ

Although this distressing state is of itself sufficiently troublesome to justify its inclusion in this list of diseases, a note was but recently made [1] which gives to this condition a grave significance. The note is to the effect that pruritus may be a prodromal symptom of malignant growth, as it is encountered not only in the cachectic stage or in association with jaundice, but in the early stages when the patient is feeling quite well. The pruritus in these cases may be either generalised or perineal. This is not only noticed in Germany, but it is mentioned by Dr. Montagu of New York [2] who reports many cases of early carcinoma of the rectum, the first symptom of which was the pruritus. This topic is only mentioned to emphasise the importance of treating this complaint, and further pursuit of it is out of place here.

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[1] Epitome, *British Medical Journal*, June 28, 1924. H. Kuttner, *Zentralbl. f. Chir.*, April 19, 1924, p. 824.

[2] *Pruritus of the Perineum*, by Joseph Franklin Montagu, M.D., New York (P. B. Hoeber, Inc., 1924).

The actual cause of this obstinate condition may explain why the ultra-violet radiation should have so good an effect. It has already been said that ultra-violet rays seem to exert a biologic action in the neighbourhood of inter-epithelial nerve fibrils; but if the pruritus be caused by the *Staphylococcus albus* and the *Bacillus coli communis*, then the lethal effect of ultra-violet radiation will readily account for the death of these micro-organisms and the cessation of the intolerable irritation, the insistent call to scratch, and the resultant insomnia.

In this disease there may have to be some preparation of the patient. If the condition has invaded the hairy skin, all the hairs should be cut short, as each hair casts a shadow which obstructs the light. The parts should be thoroughly cleansed with soap and water and dried carefully. Any crusts should be removed. With the hands, in rubber gloves if preferred, the parts should be smoothed out in order that the rays may sterilise all the folds and recesses.

The water-cooled lamp is used at a distance of 3 inches for four minutes, increasing one to two minutes each treatment. One treatment is given in the first week, two treatments the second week, and one treatment every one or two weeks thereafter. Six to twelve treatments are usually needed for permanent relief. The first treatment allays irritation to some extent, not because the bacteria are all destroyed, but because the light acts as an analgesic to the nerve endings.

In giving these details, as in other cases, it may be said that they are suitable for most patients, but will have to be varied according to the nature of the case, area of distribution, etc.

In pruritus vulvæ the patient should be warned that the reaction may be sufficiently severe to necessitate her staying in bed for a day or two; but her previous sufferings will usually cause her cheerfully to assent to a temporary suspension of her walking activities.

RHINOPHYMA

I have no experience of the exclusive use of the ultra-violet rays in this disease, but have used it with signal success in conjunction with X-rays. A first degree plus erythema, three or four times a week, and applied over a period of several months, is all that seems necessary. In one case the greasy feeling of the skin was much improved after six or seven exposures. The nose was no longer cold. The ducts of the skin ceased to fill up with sebum, and the redness became much paler.

Another case was that of a man of about fifty-seven years of age, who complained that his nose was increasing in size, was red, and attracting notice. He stated that his father suffered in the same way, and that the growth became so great as to interfere with his vision, because on account of it he could hardly open his eyes. The case was a typical rhinophyma. Six months later, with treatments thrice weekly, the nose was of normal size and appearance. This was a year ago, and when seen recently the nose still presented a perfectly natural appearance.

TELANGIECTASIS

In the past there has been no satisfactory means of removing these dilated blood vessels which occur as an unfortunate accident, or at any rate as one of the sequelæ of the use of X-rays, or of radium. Removal is sought because they are extremely unsightly, the unsightliness being due not only to the blood vessels themselves, but also to the accompanying atrophy of the glandular structure and of the fibrous tissue of the skin. My own experience is small, being limited to one area of telangiectasis over the thyroid and one large region nearly covering the anterior chest wall. Eight cases of telangiectasis treated with ultra-violet rays were quoted by Prof. H. H. Hazen in February 1922.[1]

" With an active lamp, using a quartz compression lens, I have found it necessary to give from fifteen to twenty minutes to each area. In no instance have more than two treatments been necessary to obliterate the vessels in the areas so treated. The results are a complete disappearance of the dilated blood-vessels, but naturally the atrophy of the skin remains unchanged and usually the result in appearance is that of a small, slightly whitened scar. However, these results are so encouraging that it seems worth while to record them."

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[1] *American Journal of Rontgenology.*

TINEA VERSICOLOR

This disease readily responds to ultra-violet radiation, probably by causing the death of the *microsporon furfur*. A third degree erythema is necessary. The Krohmeyer lamp in contact with each patch is used, and one or two radiations usually suffice.

URTICARIA

In chronic urticaria mild applications of ultra-violet rays usually suffice to relieve the intense itching and to clear up the condition. If the disease be not too extensive a second degree erythema with the water-cooled lamp every three or four days is administered, with a radiation of the entire body from the carbon arc for the systemic effect. When the areas are extensive the air-cooled lamp or the carbon arc may be used, all depending upon the amount of skin involved.

ULCERS

Chronic ulcers of various kinds, including those associated with varicose veins, and following X-ray dermatitis, respond more quickly to ultra-violet radiation than to any other method; the object in view being mild stimulation, coupled with sterilisation of the surface. The dose should not exceed a second degree erythema produced by the water-cooled lamp at 2½ inches, and repeated weekly. Healthy granulation is soon established, and epithelium quickly appears.

X-RAY DERMATITIS

The treatment of this serious condition by ultra-violet radiation is given by Major Sampson, who has had much experience and speaks with enthusiasm of it. He gives to the ulcer an initial dose of two or three times a fourth degree erythema dose, and in a day or two, if the reaction does not show a proper intensity, an even larger dose. After one or two heavy reactions have been induced the exposures are reduced so as not to destroy the granulation. Each ultra-violet radiation is preceded by an exposure to the high candle-power light, but there are many other details of this treatment which it is well worth while to study in Major Sampson's book.

This concludes an astonishingly long list of skin diseases. I am not claiming either now, or when on the crest of the most optimistic wave, that the ultra-violet light will always cure all, or, indeed, any of them; but it must be pointed out that at some time or other in the last ten years, each of these diseases has been treated with the ultra-violet light, in most cases with

success and in many with benefit. Furthermore, in ultra-violet light therapy we have a remedy incapable (when used with ordinary care) of inflicting injury to the skin, and a remedy, moreover, which has a rational basis from which a fabric of therapeutic benefit may be expected to arise, and, having arisen, to stand firm.

ARTIFICIAL SUNLIGHT AND ITS OTHER THERAPEUTIC USES

CHAPTER VII

ARTIFICIAL SUNLIGHT AND ITS OTHER THERAPEUTIC USES

When discussing the general therapeutics of ultra-violet radiation it was shown that these rays were absorbed in the superficial capillaries of the skin, and gave rise to several very important modifications in the metabolism of the patient. By no other means in our power can these alterations in the blood be induced so simply, safely, and surely. It is only by a careful consideration of these changes that we can come to any conclusion as to the class of disease likely to derive benefit from treatment by ultra-violet rays. For example, anæmic conditions will benefit from the increase in the number of blood cells; rickets from the increase in calcium salts, which will also be a factor in the benefit obtained in surgical tuberculosis, where the increased bactericidal power of the blood is perhaps the dominant consideration. Many diseases will occur to the mind in which it must be useful to be able to give the patient the advantages of these and other properties, such as the phosphorus increase induced by ultra-violet radiation. Where we can induce an improvement in the general health, increased resistance to disease or improvement of the vaso-motor tone by any agent, the indications for the use of that agent grow and multiply in the mind with extraordinary rapidity. Apart from sufferers from severe or well-defined illness, there are convalescents who are now, as a rule, advised to go to the seaside for "a change of air," and the tonic effect of the seaside. I have no wish to decry this venerable and valuable prescription, but it is not always within the range of practical politics. Similar, but not quite identical, are those cases, both young and old, whose ailments are classed under the head of *general debility*; delicate, easily-tired, perhaps irritable, but never-feeling-well children or adults in whom the most careful examination by the most skilled physicians and specialists fails to reveal traces of actual disease. The effect upon the general condition of these patients is most remarkable with ultra-violet light treatment. The irritability and fractiousness go; the appetite returns, with increase of body weight and strength. They no longer catch colds readily, and, with the improvement in the blood conditions, they feel day by day in every way brighter and better as their resistance to disease increases.

One other important effect of ultra-violet radiation must be mentioned, and that is the rejuvenating properties it possesses. This is no new knowledge. The sacred writings of the Hindus, written thousands of years ago, state that the sun's rays were able to restore vigour

to the muscles and brighten the intellect of the elderly.

In his published works Lorand praises sunshine as a treatment for old age,[1] and later adds a series of new facts, especially of his own observation, on the rejuvenating effects of the ultra-violet rays.[2]

He quotes several cases in support of this. One I venture to insert here.

> "The patient was a merchant of fifty-two years, who two years previously had been operated upon for duodenal ulcer. He was an anæmic, very weak man, not equal to any lengthy walks, and looking fully as old as his age warranted. Ultra-violet radiation from the air-cooled mercury vapour lamp was administered daily in addition to a very mild water cure. After three weeks of daily exposure to the rays this patient could hardly be recognised as the same man. He then appeared to be between thirty-five and forty years of age and presented an aspect of blooming health with rosy cheeks. He had also gained more than 10 lb. in weight."

Lorand is of the opinion that the rejuvenation is brought about by stimulation of the endocrine glands, especially the thyroid and the sexual glands.

The ultra-violet radiation undoubtedly has a marked influence upon muscular agility. After even one treatment, patients usually note a disappearance of lassitude and fatigue, and they become conscious of a feeling of well-being and of a capacity to enjoy life which before the radiation they had almost forgotten. Not only is a rejuvenation of the body effected, but there is an improvement in the mental capacity. Patients will show more interest in reading " dry " matter, and find it easier to memorise what they read. Ideas flow more readily, and new powers of expression come with the other manifestations of rejuvenation.

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[1] *Old Age Deferred.*

[2] *Life-Shortening Habits and Rejuvenation.*

These effects of ultra-violet radiation upon the system in general throw a good deal of light upon its effect in the various diseases in particular, and some of these latter will now be considered under their respective headings.

Alimentary System

There are several diseases, or pathological conditions of the alimentary system, in which ultra-violet radiation has proved of real benefit. It has been used a great deal in hyperacidity, chronic gastritis, and gastric and duodenal ulcers. Ultra-violet energy applied over the gastric region usually lessens or relieves the pain of these diseases.

Pacini observed at a *Stomac-clinic*, where patients were undergoing a fractional test-meal examination for various disorders, that the gastric juice removed from the stomach during ultra-violet radiation shows a diminution in its acid content. The radiations were applied without regard to the clinical diagnosis, and resulted always in a prompt drop in the total acid curve, as determined by H-ion titration against colour standards. The air-cooled quartz lamp was employed in these observations.

Clinically, ultra-violet light often quickly

relieves hyperacidity in certain miscellaneous disorders involving the secretory function of the stomach, and it is probable that the mechanism involved in this reaction plays an important part in effecting symptomatic relief in gastric ulcer. Certain it is that the pain of a gastric ulcer will sometimes clear up as quickly and as effectually as when a hypodermic injection of morphine has been given. Of course there are other factors at work besides the lowering of the acid content. With the erythema produced, there is an increase in the elimination of toxins, and even their production is lessened by the destruction of the bacteria producing them. As has been seen, this action can take place at some distance from the area treated, and is due to the changed condition of the blood stream by the absorption of the ultra-violet rays and its remote effects.

The air-cooled mercury vapour quartz lamp is most suited for this group of diseases. A light erythema (first or second degree) should be produced over the anterior surface of the body from the level of the fourth rib to that of the umbilicus. Treatment should be repeated daily.

Similar applications are of service in cases of congested liver or in cirrhosis of that organ. It is doubtful if any therapeutic measure effects as much good as ultra-violet therapy in diseases of the liver. The reaction induced profoundly influences the blood supply. It is of great service in aiding in the relief of chronic inflammation of the gall bladder. It allays the pain and tenderness, because it lessens the congestion. Since the erythema diverts the blood supply from the congested liver to the skin area over it, it tends to lessen the portal circulation, and is thus of use in those cases which tend to develop anasarca.

In this case the whole of the area which covers the liver should be treated and a hyperæmia induced. Where the patient lives at a distance a third degree erythema should be given, and treatment repeated as the reaction subsides, probably every four or five days.

Ultra-violet rays are used in the treatment of hæmorrhoids. The cases suitable are those which do not bleed, or do so only slightly, the intero-external variety which protrude and are painful. The water-cooled lamp with the special hæmorrhoid applicator is used, and a third degree erythema dose is administered. The applicator should be in contact and firmly held in its holder to avoid its slipping into the rectum through a sudden spasm of the sphincters. I have sometimes found difficulty in its painless introduction, and I have found it very useful to apply a small vibrator to the back of the applicator which causes the muscles to relax so that the applicator enters without distress. Congestion naturally follows the treatment. As it subsides there is a shrinkage of the hæmorrhoids, and a relief from the pain. Treatment should be repeated when the reaction clears up.

OBESITY

The effect of ultra-violet radiation on very fat or very thin patients would at first view

appear a paradox, for the thin patients increase in weight, while reduction in weight occurs in the obese. The increase in weight in the thin persons is due to the increase in the bulk of the muscles caused by the processes of increased oxidation, while the identical process of increased oxidation in fat people causes the fat in the system to be better burnt up and a reduction in weight results. As Lorand says: "Thus we observe a considerable loss of weight both after treatment by natural sunlight in regions with an abundance of ultra-violet rays, and after treatment with the quartz light, stout women and men becoming transformed into persons with a more youthful appearance. On the other hand, under such treatment, thin skinny bodies develop rounder forms."

I do not recommend the treatment of obesity by means of the ultra-violet light. Electricity has other and better means at its disposal than this; but, as it is a state of disordered metabolism, accompanied by superfluous adipose deposits and various functional disturbances, it is interesting to note that an agent such as the ultra-violet light, which profoundly and beneficially affects metabolism, does so in a disorder which is so basically metabolic.

THE CIRCULATORY SYSTEM

It will be easily understood that when the total surface of the skin is exposed to ultra-violet radiation the general circulation will be influenced considerably. For not only in the dilated capillaries is the blood brought to the surface and exposed to the ultra-violet radiation, but there is the deeper action of the depletion of other organs and vessels due to the filling of the capillaries. Thus, it is only to be expected that in cases of pathological blood pressure we may notice its reduction. Dr. Hugo Bach [1] was one of the first to point this out, and he says definitely, "The radiations with the ultra-violet quartz light diminished blood pressure. Radiations of the entire body are not necessary, but it is sufficient to treat only parts of the body with the rays." Control tests were made with an air-bath without ultra-violet radiation and there was no fall in blood pressure. Later, these observations were corroborated by the late Dr. Malgat [2] of Nice, and again confirmed at the Congress of Monaco, April 1920.[3] In addition to the fall in blood pressure, a feeling of rest and freshness is induced, and the accompanying insomnia or headache disappears.

The method of applying the ultra-violet radiation may consist of the use either of the carbon arc bath or of the air-cooled mercury vapour lamp. The former is applied to the entire body at the same time, with two to three banks of 25 ampère arcs at 24 inches from the skin, one bank directed on to the chest and the other on to the back for ten minutes, the bath should be given daily and the period of its duration increased two to three minutes a day. Should there be much reaction and any soreness of the skin, treatment should be suspended for one, two, or three days. With the latter, the radiations are applied to successive areas of the skin, the whole surface of the body being covered in the course of a week. A second degree erythema should be produced if this method be adopted.

In either case, during the treatment, and indeed after, the dilatation of the cutaneous vessels relieves the work of the heart; and toxic products in circulation (which are giving rise to spasm of the small vessels through irritation of the vaso-motor centres) are greatly lessened.

The action of ultra-violet radiation in the treatment of chilblains has already been mentioned. In several cases of Raynaud's disease I obtained very gratifying results by using a similar technique.

HÆMOPHILIA

This is a disorder in which it has been suggested that ultra-violet light might be of service. Little, however, is known of the pathology. The calcium is frequently, though not invariably, deficient, and the blood platelets are often, but not always diminished. As it has been shown that ultra-violet radiation increases the number of blood platelets and augments the calcium content of the blood, we have at all events, and in some cases, in sunlight, whether natural or artificial, a remedy, which, when scientifically administered, can do no harm, and must do good to the body in general, and may be of benefit to the hæmophilia in particular. And in this disease, where no remedy has yet achieved any appreciable success, it is surely worth a trial.

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[1] In a paper "Anleitung und Indikationen für Bestrahlungen mit der Quarzlampe Kunstliche Hohensonne," *Deutsche Med. Wochenschrift,* 1922, No. 9 (Verlag von Curt Kabitzsch, Leipzig).

[2] *La cure solaire de la tuberculose* (Paris, 1911).

[3] *L'heliotherapie, complement du traitement climatique par Docteur D'Oelsnitz.*

Genito-Urinary System

There are at least two conditions of this system in which ultra-violet rays have rendered good service. They are nephritis and prostatitis. Their use in chronic renal disease was foreshadowed by Rollier when he observed the favourable influence of the helio-alpine treatment in cases of amyloid disease. Not only did severe cases survive longer than was expected, but early cases recovered completely.

The beneficial effect of ultra-violet radiation in nephritis is probably due to the hyperæmia it produces on the skin over the kidney area, which in its turn creates a secondary or subsequent hyperæmia in those organs. Various treatments have, in time past, been used in chronic renal disease, which have produced a hyperæmia of the skin over the renal region such as the permanent hot-water bath of Strauss, cupping, and the treatment of Bier, but there is no way in which this arterial hyperæmia of the kidney can be produced more gradually and permanently than

by ultra-violet radiation. It is one of the many instances that could be cited, known to all workers in this form of therapy, where the inflammatory stimulus of the superficial hyperæmia extends to an entirely different territory having no direct connection with it. Dr. Amstad states that the superficial hyperæmia exerts a favourable influence on degenerative processes of the kidney, and specifies three cases of disease of the kidney of different ætiology (tuberculosis, syphilis, and that following osteomyelitis) on which he based his opinion. In all of these cases there was diminution of the albumin, improved function, and no symptoms of renal irritation, such as red corpuscles in the urine, or other manifestation of undue stimulation. In the United States, for some time ultra-violet radiation has been used in cases of nephritis; the improvement which followed the treatment (disappearance of casts and albumin) being attributed to the improvement in the tissues of the body as a whole as the elimination is increased, especially of urea and creatinin.[1] Sampson increases the hyperæmia of the kidney by applying diathermy directly through it and says, "If to this (diathermy) are added the markedly oxidizing, eliminating, and auto-anæmic properties of tonic applications of the ultra-violet light, we have a treatment based upon physics, chemistry and logic, and one that, in connection with the other usual treatment measures, will often be astonishing."

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[1] *Actinic-Ray Therapy*, by T. Howard Plank (3rd edition, 1922).

There is room for much research into the relation of ultra-violet radiation and nephritis, but enough has been said to justify the cautious administration of a remedy which is safe, and from which one may logically expect good to result. The open air-cooled lamp locally and the carbon arc body-bath are the forms of ultra-violet radiation used in the treatment of nephritis.

PROSTATITIS AND ENLARGED PROSTATE

In the large spongy, hypertrophied condition of the prostate, ultra-violet rays from the water-cooled lamp give much relief. Not only is the necessity of frequent micturition relieved, but there is a gradual reduction in the size of the glandular enlargement. The success or otherwise of the treatment will depend upon the length of time the condition has existed, because in long standing cases the fibrous tissue in the gland will predominate to a greater extent; but even in these cases an abatement of the inflammatory process and an improvement in the symptoms may be anticipated. It is not suggested that it is a counsel of perfection to treat enlarged prostates with ultra-violet radiation. In other forms of electricity there are several methods of treating a condition which so tries alike the skill of the physician and the endurance of the patient. But in a work on the subject of ultra-violet radiation this therapeutic measure must be mentioned in regard to a disease which affects

about one-third of all men over sixty years of age and in which medicine offers so little and surgery only such an operation as prostatectomy.

The rays are administered per rectum through a rectal speculum, care being taken that the rays are directed at, and not past, the gland. A dose equivalent to a second or third degree erythema should be given twice weekly.

CYSTITIS

It is with some diffidence I mention this troublesome disorder and the inexplicable results following ultra-violet radiation in attempts at relief of the symptoms. Relief from pain follows the application of ultra-violet rays applied to the lower abdominal region, and with persistent raying, frequency of micturition abates and tenesmus becomes less troublesome. I have not had an opportunity of trying the effect of inserting a quartz rod into the bladder, but it would seem to be a logical procedure to follow and one would expect a sterilisation of the bladder contents.

GYNÆCOLOGY

Amenorrhœa, Dysmenorrhœa, Menorrhagia, Metritis, and Ovaritis

The good effects of the ultra-violet rays upon the endocrine and sexual glands has already been noted. It is due to this fact, that in Southern countries, with a light, rich in ultra-violet rays, menstruation appears in girls at an earlier age than in the Northern Temperate regions. Also, within the Arctic Circle, during the Polar night, in the native women, menstruation frequently ceases, reappearing only after the sun has returned.

Ultra-violet radiation is capable of yielding very good results in the treatment of disorders of the uterus and ovaries, and in those cases where menstruation has been absent for a long time it can be used with much benefit.

Disordered menstruation, where there are no local pathological lesions, means some alteration of the function of the endocrine glands, and, as has been shown, ultra-violet radiation stimulates the activity of these glands. After treatment by the carbon-arc general body bath, I have seen complete restoration of function, and it seems logical to argue from this that its use in cases of sterility is indicated.

The application of the air-cooled quartz lamp over the lower abdomen and upper third of the thighs daily to the point of toleration of the patient (first degree plus erythema), and also over the lower dorsal and lumbar region, will serve for all of the gynæcological conditions mentioned.

In addition to this treatment in gynæcological conditions the general body bath with the carbon arcs is of the greatest value, and should always be used to reinforce the local treatment. Patients are very apt to allow the upper part of their bathing drawers to cover the ovarian region. It should be explained to them that it is of importance that the rays should reach this region.

Erosion of the cervix improves readily under the application of the ultra-violet rays. They are applied with a special applicator with a quartz lens by compression on to the cervix for two minutes ; the treatment to be repeated when there are no further signs of reaction. At each sitting the dose (*i.e.* the time of exposure) should be increased. This must be judged by the amount of reaction produced by the initial dose.

Menorrhagia

During the time that a patient is undergoing X-ray treatment for the production of an artificial menopause, the carbon arc body bath is of service in two ways. Firstly, it brightens the outlook of the patient on life in general and creates a feeling of cheerfulness and well-being which is usually absent at the menopause, whether natural or artificial. And, secondly, by raising the calcium content it helps to increase the coagulability of the blood and thus aids in avoiding profuse hæmorrhages.

The management of functional menorrhagia in young girls sometimes presents great difficulty, and often the menstruation continues until a serious form of anæmia ensues. Here, of course, for obvious reasons one would hesitate to employ X-ray therapy. But treatment by ultra-violet radiation is distinctly indicated and will often prove effectual where cotarnin and other drugs, curettage and other gynæcological treatments, have been of little or no avail. Whether the results are due to the increased calcium content in the blood, or to some action of the calcium on the ovaries, or to some effect of the ultra-violet radiation on the ovaries themselves, remains to be determined. This can be left to the research worker. For the clinician, there is a valuable form of treatment in a disorder presenting no small difficulty.

Leucorrhœa

Where the origin of the discharge is cervical there are many better methods than ultra-violet radiation, because they are easier of application; but when the leucorrhœa is a symptom of vaginitis, a second degree erythema produced from the Krohmeyer lamp, applied through a speculum twice weekly, will clear it up in a very short while.

Respiratory System: Bronchial Asthma

It is not easy to see the rationale of the treatment of asthma by ultra-violet radiation. I tried it first, purely empirically, on a colleague of mine on the staff of the 3rd London General Hospital at the suggestion of Sir Bruce Bruce-Porter, our commanding officer. A tungsten arc lamp was used with a current of ampères 15 and volts 100. It was placed 12 inches from the chest, and a like dose was applied to the back. Each area was exposed for five minutes. The treatment was followed by a symptomatic improvement which was repeated on subsequent occasions. Nowadays I use the air-cooled mercury vapour lamp, beginning at 20 inches for

three minutes, repeating and increasing the dose as the condition of the skin will allow.

The general carbon arc body bath twice a week for six weeks as a complement to the local treatment is usually much appreciated by the patient and tends to hasten recovery.

Pleural Adhesions of a Non-Tubercular Origin

Rollier is of opinion that in these cases heliotherapy has not only a stimulating action on the whole body, but will also directly aid the regression of the adhesions.

Pulmonary Tuberculosis. See *Tuberculosis*.

The Nervous System

Neurasthenia, or Nerve Exhaustion

There is no disease in which greater benefit may be derived from ultra-violet radiation than this. Care must be taken that the application should be tonic or stimulative in character. The good effect of the light may be due to the alteration in the blood chemistry, the endocrine balance, or to the bactericidal improvement in the blood, or to all three. In writing a prescription for the neurasthenic are not the names of the two drugs which rise readily to the mind, phosphorus and calcium, and is not one of the most usual prescriptions, glycerophosphate of calcium? And it has been said already that ultra-violet radiation raises the calcium and phosphorus content in the blood. It has likewise been mentioned, this form of treatment stimulates the action of flagging endocrine glands and increases their activity. Lastly, as insisted upon by Sir Bruce Bruce-Porter, neurasthenics invariably suffer from chronic intestinal toxæmia; and since it is established that the exposure of the whole body to ultra-violet radiation increases the bactericidal power of the blood, it should naturally follow that this power, acting on the micro-organisms which find their way into the blood, should have a definite limiting effect on the production of those toxins which are causing the neurasthenia. With this limitation of bacteria and the checking of the toxin supply, the various symptoms of the neurasthenic will decrease. Certain it is, whatever may be the actual explanation, there are few treatments for which the neurasthenic will be so profoundly grateful as ultra-violet radiation. One advantage, and in the treatment of neurasthenia it is a double advantage, is that it involves no going away from business. The treatment should be given daily, and the patient encouraged to go on with his usual avocation. His mind then has something upon which to dwell, other than his own symptoms. For few things are worse for these patients than time for introspection. Under treatment, they find day by day that they can take more interest in their work, and that, however slowly, the power of concentration gradually returns and the periods of content occur more frequently, replacing the continued depression.

As to the manner of application of the rays, much must depend upon the individual case. For the majority of cases the general carbon arc bath is suitable. In some cases of post-operative neurasthenia it may be well to apply the air-cooled mercury vapour lamp to the area of the operation. In other cases application to the spine or to the liver region will suggest itself. No treatment, however, of neurasthenia must tire or exhaust the patient. He should be encouraged to relax his body and cultivate a peaceful state of mind.

There is no doubt that relatives and friends are often a drawback to the neurasthenic's progress towards health and peace of mind, and a hint dropped to them, or to the patient to this effect, may be of great value. As a tactful measure that admirable apophthegm may be quoted :

> Peace, perfect peace is found, they say,
> Only with loved ones far away.

Ultra-violet radiation will naturally suggest itself in many mental conditions—melancholia, for instance. Remembering that by ultra-violet radiation of the whole body its phosphorus content is raised, it is interesting to note that in a recent article in *The Lancet* (1924, ii. 218), entitled "The Phosphate Ratio in Mental Disease," Drs. William Moodie and Eileen A. Boyd showed that this is an important factor in dealing with insanity, and cases were quoted of paraphrenia, dementia præcox, and maniac depressive insanity, in which the phosphate ratio had dropped. It may be that this would give us a key to a treatment for some forms of insanity.

Sciatica, and other Forms of Neuritis

The technique of the treatment for the different forms of neuritis is about the same. The water-cooled lamp with a quartz lens is used and pressed in contact over the entire length of the skin overlying the nerve course, or where definite local areas of pain or sensitiveness along the course of the nerve can be made out, these may be treated individually. A third degree erythema should be produced. The pressure of the lamp should not be so severe as to cause pain on the supersensitive nerve. The reaction usually takes place as follows: A few hours after the treatment there is a reddening of the skin. This reddening becomes more intense, and blisters form when the reaction has been strong enough. At a period of from twenty to twenty-four hours the reaction is at its height. Then its intensity decreases. At the end of three or four days inflammation has disappeared, and there remains only some skin pigmentation which lasts for a longer or shorter period. The number of treatments needed for success is very variable. In some cases of recent origin, where one would expect that a few treatments would suffice, the exposures have to be repeated five to seven and even nine to ten times.

On the other hand, old chronic cases of several years' standing clear up in a surprisingly short space of time.

Myelitis, Locomotor Ataxia, and Anterior Poliomyelitis

It cannot be expected that ultra-violet radiation can cure any organic disease of the spinal cord. Nevertheless, irradiation of the skin over the spinal column is certainly effective. Apart from the improvement in the general health of the patient, there is observed quite frequently a considerable degree of improvement in the local manifestations of the disease, *e.g.* in locomotor ataxia, irradiation of the skin over the spinal areas involved often furnishes a relief from the distressing "lightning pains," and though reflexes once lost do not return, after continued application it is observed that co-ordination has so improved that the gait becomes more natural. Lastly, some orthopædists consider that the paralysed, cold, badly vascularised limbs of cases of poliomyelitis would be benefited by ultra-violet radiation.

Lumbago, and other Forms of Fibrositis

If Gowers' theory be correct that lumbago, and presumably other forms of fibrositis, are due to an inflammation of the fibrous tissue with which the different nerve endings (muscle spindles) are surrounded, then it is easy of comprehension why the erythema produced by ultra-violet energy should successfully combat the pains of fibrositis. Apart from any chemical or other action, where there is a hyperæmia, *i.e.* a filling of the capillaries, a depletion of the deeper vessels must ensue, and this depletion relieves the inflammation of, or pressure on the fibrous tissue; and with the relief of pressure comes the relief from the pain.

But it may be of advantage to go a little more fully into the root of the matter owing to the extremely common incidence of the disease. Is the fibrositis a manifestation of a disordered metabolism, or is a bacterial infection the ætiological factor? In all probability, I think, there are three forms of fibrositis, the purely metabolic form, the form due to a focal sepsis, and, lastly, a mixed form, that is, in fibrositis, occurring where there existed faulty metabolic conditions (such as a gouty diathesis) plus a superadded bacterial infection. It follows that a very careful search should be made for the focal infection before embarking upon treatment. Putting in parallel columns the pathogenesis of fibrositis and the manner in which the general body bath acts, and the therapeutic effect of the ultra-violet radiation locally, it can readily be seen why cases of fibrositis yield to this form of treatment.

Rheumatism, Articular and Muscular

Most of the authorities, in writing on the various rheumatic affections, recommend that

every effort should be made to increase the resistance of the body to cold and damp, etc. To do this, heliotherapy is the course one would like to recommend, but in countries where this is not possible, ultra-violet radiation, till all the skin of the body is well tanned, will prove a very efficient substitute.

Fractures, Osteomalacic, and Others

The same argument would apply in the treatment of fractures. The object of applying sunlight, or in its absence, ultra-violet radiation, is to favour the repression of the œdema, and to maintain the strength of the muscles and to safeguard the articular function. For as the radiation causes a diminution of pain, so it favours the early introduction of movement. This was observed by Dr. Amstad, who also mentions that "Riedel has also observed favourable results in osteomalacia, in which marked recalcification was shown by the X-rays after combined sun and quartz lamp treatment." He mentions a case of bilateral post-osteomalacic fractures of the neck of the femur, treated in the ordinary way for a year and a half without showing any tendency to calcify, which healed in a relatively short time and with good ossification by treatment by the ultra-violet rays. Again, after an operation for pseudoarthrosis and after an osteotomy operation, he witnessed the stimulating action of heliotherapy on ossification.

SPECIAL SENSES

In diseases of the eye, ultra-violet rays have been used in trachoma and tubercular conjunctivitis. In the latter disease a third degree erythema dose was given with good result. The water-cooled lamp was used with a quartz rod applicator compressing the tissues at an angle of 45°.[1]

In diseases of the ear, with foul purulent discharge (in one case after operation), very good results have been obtained from the Krohmeyer lamp, using a quartz applicator inserted through an aural speculum into the canal as far as possible up to the tympanum. A second degree erythema dose was given. The air-cooled lamp was applied over the mastoid cells at the same time.

In a recent case of mumps the earache and pain were not only brought to an irreducible minimum, but the whole course of the disease was modified and the symptoms were rendered comparatively insignificant. The treatment adopted was the general body carbon arc bath and local applications of a high candle-power lamp. Although this is only one case, the results were so striking and successful that it is a treatment which should certainly be given a further trial in this distressing complaint.

Very good results are reported by Burroughs [2] in suppurative conditions of the ear, and also in cases of middle-ear deafness generally. Burroughs uses the tungsten arc for about one and a quarter minutes, directing the rays by means of the reflector through a suitable speculum to the tympanum, and giving a one-minute application over the mastoid cells, also with the reflector. The treatment is repeated every two or three days, and the time lengthened at each successive sitting. The improvement in the hearing is, as a rule, noticeable after the fifth treatment.

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[1] Sampson.

[2] *The Lancet*, October 29, 1921.

DISEASES OF THE NOSE

Hay Fever

The results obtained by using ultra-violet radiation in this condition have proved more satisfactory than those obtained by any other method. The particular technique was shown me by Dr. Norman Titus, of New York. Two years ago, at the annual meeting of the American Electrotherapeutic Association, he spoke as follows :

" First of all, I do not believe that the ultra-violet light has any effect on the pollen which is causing the condition. I *know* that it has a great germicidal effect, and by applying the light to the nasal mucous membrane we relieve the membrane of some of its normal work in taking care of the bacteria which stick to it in breathing. In relieving this mucous membrane from some of its ordinary work we allow it to give more attention, as it were, to handling the pollen. To explain this more concretely we might assume the following situation. Granting that 1 sq. mm. of nasal mucous membrane has 10 units of immune capacity, we can suppose that 7 units of this are required to handle the ordinary bacteria that come into contact with this area. When there is an over-exposure of this area to a large contamination of any organism, such as the pneumococcus, if this overload requires more than the available 3 units that are in reserve, the individual suffers from the result of the infection, and acquires a coryza. A similar circumstance to this overload occurs when pollen comes in contact with this area. The patient being specifically anaphylactic to the pollen, the 3 units in reserve are not sufficient to keep down the symptoms and the patient has hay fever. When ultra-violet light is used it relieves the mucous membrane of some of its load requiring 7 units, and allows the mucous membrane to combat the pollen with a total of units sufficient to handle the condition, but not calling for more than the 10 units of immunity it has on hand.

"It has been found at Johns Hopkins Hospital that patients suffering from anaphylactic reaction in general have a lowered calcium metabolism, and that ultra-violet given to the whole body will increase the calcium metabolism. Therefore it is rational to combine the intra-nasal ultra-violet treatment with general baths with the air-cooled lamp. In my regular treatments I also precede the intra-nasal application with at least five minutes' treatment to each

side of the nose with the non-vacuum electrode energised with the Oudin current." The treatment consists in "ironing" the nasal mucosa with the electrode.

It has been repeatedly noticed, more especially in Germany, that patients who suffer from Hay Fever are deficient in calcium retention, and that the internal administration of calcium given continuously for a period of from two to three years has given relief to patients, even though they have suffered from Hay Fever for twenty years or more. If this be true it follows logically that in ultra-violet radiation, which raises the calcium content of the blood, we have a means of combating this obstinate disease more efficaciously than by the internal administration of the curative salt. The internal administration of calcium has, it is well known, certain drawbacks, chief among which is the liability to cause gastric disturbance, which, of course, is avoided when the calcium content is raised by means of ultra-violet radiation.

Last summer at the suggestion of, and in conjunction with, Mr. Philip Franklin, in addition to ultra-violet radiation of the cavities, ionisation of the nasal mucous membrane was undertaken. Mr. Franklin carefully packed every available millimetre with gauze soaked in a 1 per cent. solution of chloride of zinc.

Upon the skill and care with which this packing is done depends in a very great measure the success of the treatment. A current of 2 to 3 milliampères was very slowly turned on for a period of ten minutes, it was then slowly turned off. The current was derived from the main with a water-rheostat interposed. We treated twelve cases in all, and though it is too early to speak with any degree of assurance, there seemed to be improvement in all but one of the cases. These cases were all undertaken in the height of the hay-fever season. They have promised to return this year, two or three weeks before the expected date of onset of their attacks.

Hypertrophied Turbinates, Ozæna, Atrophic Rhinitis

Much may be done in these affections with the ultra-violet ray. All scabs or crusts should be first removed to allow the rays free access to the diseased tissues. The cavities should be well cleaned. The Krohmeyer lamp is used with the short quartz rod inserted into the nasal cavity. A third degree erythema dose, usually about two minutes, is given and repeated every other day should the tolerance of the mucous membrane permit. The more of the mucous membrane that is treated the quicker will the result be obtained.

Sinus Infection

Sinuses, having been opened up and pus removed, lend themselves readily to treatment with the water-cooled lamp. They respond favourably to the bactericidal influence of the rays and usually after two or three treatments it is found that there is a relief from pain and an improvement and a diminution in the discharge. The technique is the same as for nasal treatment.

Diseases of the Throat

Pharyngitis, Laryngitis, Tonsillitis

Gratifying results have been experienced with ultra-violet therapy in these diseases and in properly selected cases. In them, as in other special branches, team work is essential to consistent success. It is useless to expect radiation of the tonsils and pharynx to clean up a nasopharyngeal infection in a patient whose septum is badly deflected, with ethmoid cells blocked and suppurating. These diseases, too, are among those which derive extreme benefit from a combination of X-ray and ultra-violet therapy.

Pyorrhœa

There is no doubt but that by a daily application of ultra-violet radiation this condition can be very much improved or at least checked. It can be even cured *symptomatically*, but I have yet to see a case of true pyorrhœa cured permanently by its means.

Turrell has devised two special specula of brightly polished metal. The patient holds a piece of stiff cardboard in front of his face with one end of the speculum fitted in it. The other end rests on the patient's gums. With the tungsten arc burning evenly, the doctor holds the reflector and guides the beam of light on to the gum. The treatment lasts until the patient feels a sensation of warmth, which is usually three to five minutes.

Last January Mr. P. S. Campkin showed an apparatus for applying ultra-violet rays in the mouth.[1] The device consists of a mirror and two quartz lenses of different powers, all of 41 mm. diameter and mounted on short handles connected with a pivot hinge. The mirror is adjusted so that the patient can see the interior of his own mouth when the lenses, which are permeable to ultra-violet rays, are arranged to focus the sun's rays on an area of about the size of a threepenny-piece. For irradiating areas in the front of the mouth the two lenses are superimposed. If a longer focal length be desired—*e.g.* for the back of the mouth—one lens may be pushed aside. Should sunlight not be available, the light from a mercury vapour or an arc lamp can be substituted. This instrument can not only be used for pyorrhœa and its prophylaxis, but would be useful in the treatment of several oral lesions. It would assist in promoting the healing of raw surfaces following tooth extraction or the removal of cysts, in marginal gingivitis and after the excision of hypertrophied gums.

Then lastly, and these parhaps are the most simple, there are the special quartz applicators for use with the Krohmeyer lamp. Sampson uses these and has made a special study of pyorrhœa, and devotes a chapter to the subject in his book.

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[1] *The Lancet*, February 9, 1924.

SYSTEMIC AND MISCELLANEOUS DISEASES

TUBERCULOSIS

Under this heading first comes tuberculosis in its various forms. This again is one of the few conditions about which, in connection with ultra-violet therapy, much has been written. No attempt therefore will be made here to discuss it with any degree of completeness.

Let it be understood at the outset that the counsel of perfection for the treatment of tuberculosis, as a rule, whether it manifest itself in lung or gland, in bone or skin, is to send the case to a high altitude for treatment by heliotherapy, and this too, *as soon as the discovery of the disease is made.*

The sun cure in the high mountains is now generally admitted to be the most satisfactory method of treatment in the large majority of cases of surgical or localised tuberculosis. But it is in a foggy country like this, where the climatic conditions do not lend themselves readily to living without clothes, and where sunny mountain tops are not always available, that we must look for the next best thing, and it is in the artificial sunlight that we find it. It has been already pointed out that, as a therapeutic measure, it is in some ways even a better remedial agent, and serves the purpose of the patient more accurately and scientifically than actual sunlight.

It must be premised as an article of faith that every case of tuberculosis should be treated with *ultra-violet radiation whether this be derived from the sun or from an electric arc.*

In patients suffering from *pulmonary* tuberculosis ultra-violet radiation must be administered with extreme caution. The treatment must not be too vigorous at the beginning. Should the local application of the rays be followed by an increase of temperature, even of 1° F., or a rise in the pulse rate, it is of doubtful wisdom to persevere at that time, and if persisted in, the patient will require minimum doses and careful and continuous observation.

The type of pulmonary tuberculosis which is most suitable for treatment by ultra-violet radiation is where the disease is of the localised, single-focus type, especially if there be little or no fever. The cases that do not do so well are those of multiple foci, where there is a definite rise and fall in the temperature, and in patients prone to hæmoptysis.

It seems imperative in all forms of tuberculosis to which ultra-violet radiation is applied, to administer both general and local irradiations, though the general irradiation must be regarded as the more important.

In cases of surgical tuberculosis, it is difficult to restrain one's enthusiasm when speaking of ultra-violet therapy, or to refrain from quoting cases which would read as do the miracles. There is no other form of treatment in surgical tuberculosis which can compare with the effect of ultra-violet rays. Cases of Pott's disease, tubercular joints with discharging sinuses begin to improve, even after years of illness, often after the first or second treatment, and, when this takes place, progress is rapid. The sinuses heal up and cease to discharge. The general condition of the patient is brighter and better, and a complete change takes place in the entire picture. The treatment, as has been said, should be both local and general. The technique of the former is simple. The part to be treated is directly exposed, and the air-cooled lamp held, or kept in position, directly over it for three minutes. If this produce a satisfactory erythema (second degree) it should be repeated on the second or third day as the reaction subsides. At each succeeding treatment the exposure should last three minutes longer, until a total of half an hour is reached. The general body treatment has already been described. The part of the body which has been treated by the air-cooled lamp may be showing such a reaction that it may be advisable to shield it during the general administration of the light. This may readily be effected with a handkerchief.

Lupus and other tubercular manifestations of the skin have already been mentioned when speaking of dermatology.

Tubercular Peritonitis

Gauvain says that uncomplicated cases almost invariably do well, that the fibrous adhesive type often obtains rapid and permanent benefit, and that such complications as intestinal obstruction are very rare at Alton.

The treatment of tubercular ulceration differs little from that followed in treating lupus. These ulcers treated locally with some convenient lamp using the quartz mercury vapour, heal rapidly, and when the local treatment is combined with the general body bath do not break down nearly as often as one is accustomed to see in those cases which have not been submitted to artificial sunlight.

Tubercular Adenitis

In cases which have been neglected, or where the gland has suppurated and burst through the skin, ultra-violet rays will do a great deal to sterilise the wound and aid Nature to effect healing. It should be superfluous to recall the well-nigh specific effect of X-rays in tubercular glands before suppuration has taken place.

Commander William Seaman Bainbridge presented a comprehensive and masterly communication at the Congrès International de Médecine et de Pharmacie Militaire, Rome, 1923, upon "The Influence of the World War on Surgical Tuberculosis—America's Viewpoint."[1] In this paper he summarises the treatment, over a course of eighteen years, of tubercular glands by surgical measures, and gives it as his considered opinion: "These observations serve to show that the effect of surgical treatment in tuberculosis of the cervical glands is inferior to the result recently accomplished by means of light therapy and X-ray treatment."

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[1] Published in *The Military Surgeon*, August 1924.

RICKETS

This is one of the diseases most amenable to the ultra-violet energy, in which the therapeutic value of this agent has been proved beyond doubt. For over twenty years, experimental and clinical proofs have been frequently recorded. Literature, which, as a rule, is scanty where ultra-violet light is concerned, is prolific where this form of therapy is employed in rickets. Thirty-four years ago, Dr. Theobald Adrian Palm published his views on the relation of sunlight to rickets (see *The Medical Press and Circular*, May 28, 1924), and from then till the present time the medical journals have been publishing facts and results of ultra-violet radiation in the treatment of this disease, so that it would seem superfluous to enter fully into the subject here, and to discuss it superficially would be unsatisfactory.

The whole case may be summed up, somewhat baldly perhaps, by two definitions :

1. Rickets is a disease or aberrancy of the bony tissues due to, or characterised by, a calcium and phosphorus deficiency, as well as a lack of the fat soluble vitamin-A, a calcium vitamin, the anti-rachitic vitamin (Mellanby),[1] and
2. Ultra-violet therapy is one which raises the calcium and phosphorus content in the body, and also increases the energy of the fat soluble vitamin-A.

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[1] *Experimental Rickets*, "Special Report" Series, No. 93, London, H.M. Stationery Office, 1925.

If the accuracy of these two definitions be admitted, then it must be conceded that ultra-violet radiation is a virtual specific for the remedy of the pathological condition shown in rickets.

For rickets, for osteomalacia, as for all conditions in which it is sought to remedy bony defects, the method of treatment is the general irradiation of the body, either by the carbon arc or the air-cooled mercury vapour lamp.

This being established, the technique of the practical prophylaxis of rickets may be outlined.[1] The treatment should begin as soon as pregnancy is proved. In the parturient female an increased calcium content is a consummation most devoutly to be wished. There is normally a great drain upon her calcium metabolism, as is often evidenced by dental trouble, and, owing to this drain, the seeds of rickets may be sown in the child before ever it is born. Hence, both for her own welfare and that of her unborn child, let the expectant mother have some form of light therapy regularly for the duration of her pregnancy. Apart from being an insurance premium against the production of unhealthy offspring, the mother will experience a sense of health and well-being not always obtaining among women labouring with child, but which usually accompanies the administration of general light therapy.

Furthermore, treatment by light should be continued throughout the period of lactation.

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[1] *Light in the Prevention of Rickets*, F. Howard Humphris, April 1925.

What better prophylactic agent against the occurrence of rickets could be desired than the maternal milk rich in calcium salts ?

This is, of course, the Counsel of Perfection, and at the present time not practicable for the many, but it would certainly make for the prevention of rickets.

Coming now to the child who has not had these advantages derived from his mother, it has been suggested by Mellanby[1] that the anti-rachitic vitamins in the food are increased or made more active by exposure to ultra-violet radiations, and that these tend to conserve ingested calcium and phosphorus for the use of the growing organism. Another measure which would do much to eradicate this widespread disease of children would be the raying of every child for a month or six weeks during the first year of his life. Two or three times a week would be all that would be needed, and this would have far-reaching effects, and produce results at which one can only hazard a guess, but which I venture to think would be comparable to the effect that vaccination has had upon small-pox. Fifty years ago one met in the streets on every hand, eyes blinded by this scourge, and it seems to me that I can remember that one face in every ten or a dozen was pock-marked. To-day such a thing is a rarity. But rickets, its results, and the infant and child mortality, which can be traced to its malign influence, all take heavy toll, and, though the prevention of rickets by the light treatment of every child may appear extravagant at first sight, the paramount importance to the population of the prevention of rickets cannot be exaggerated. It is not only rickets as an entity which it is sought to extinguish, but just as it is recognised that rachitic children are more liable to infectious and other diseases than the non-ricketty children, so, with the prevention of rickets, the liability to many illnesses which contribute to child mortality is diminished. The prevention of rickets in the children of the nation is a national duty, and so surely as it is performed, a national reward will follow in the bringing up of a population, few of whom will appear in Class C3, but who will be sturdier and stronger by the elimination of a disease which for too long has weakened and depleted several nations.

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[1] *Experimental Rickets*, "Special Report" Series, No. 93, London, H.M. Stationery Office, 1925.

Not only in bony defects is the general use of ultra-violet radiation indicated, the flabby hypotonic child is enormously benefited by it, the dull apathetic child becomes brighter, the lazy more energetic, and the irritable, fractious child more amiable and cheery.

Rhino-laryngeal Tuberculosis

This can be treated with the carbon arc generally without any local treatment. O. Strandberg[1] gives a list of results of treatment by this method showing marked amelioration of symptoms in cases of lupus of the upper air-passages and tuberculosis of the larynx, and a cure in a good proportion. A series of histological preparations from the turbinal mucosa of a case of nasal lupus made during the course of treatment showed the gradual disappearance of tubercles, and confirmed the clinical findings. Symptoms such as hoarseness, pain, and difficulty of swallowing were rapidly and thoroughly relieved.

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[1] *Journal of Laryngology and Otology*, January 1924.

Surgical Adhesions

In addition to the instances given where ultra-violet radiation forms a valuable adjuvant to surgery, light is of the utmost use in preventing adhesions which so frequently follow abdominal operations. Its action will also improve the appearance of the scar. The application should be made as soon as possible after the operation. At first the line of incision should be protected from the rays, as young scar tissue will stand less heat than normal skin. Apart from this small detail the technique of treatment does not vary from other abdominal radiations except perhaps the high candle-power incandescent lamp may be used either in conjunction with ultra-violet radiation, or on alternate days with it. The results of the combined treatment are gratifying alike to the surgeon and to the patient.

Sprue

A very interesting article appeared recently in the *Lancet*[1] on the treatment of Sprue, from which one can only deduce that it is a disease which calls for treatment by artificial sunlight. Dr. Harold Scott says the most recent form of treatment, based on laboratory tests, is that by calcium and extract of parathyroid gland. This is, at least, founded on rational grounds, and the progress and result of the treatment can be tested in the laboratory. The fatty diarrhœa, the cramps which are often present, the œdema, the tetany in late and severe cases, may be ascribed to faulty calcium metabolism. In sprue, the ionic calcium in the serum is reduced in severe cases by as much as 30 to 40 per cent. By flooding the system with calcium this deficiency is temporarily made good and improvement ensues, and when parathyroid extract is given in small doses the symptoms have been shown to clear up with marvellous rapidity. The diarrhœa is replaced by constipation, the patient puts on weight, and his sense of well-being is restored. When it is remembered what has been said of the power of ultra-violet radiation to increase the calcium content and to stimulate parathyroid growth, it would seem that this form of therapy is an ideal measure of treatment, or, at least, an adjuvant not to be neglected.

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[1] *The Lancet*, March 21, 1925, "The Treatment of Sprue," by H. Harold Scott, M.D., M.R.C.P.

SYPHILIS

In the beginning of this chapter it was shown upon what grounds the treatment of ultra-violet radiation was based, and the nature of the pathological conditions in which it was indicated.

Its utility in tuberculosis, a chronic infectious disease similar to syphilis in many respects, is universally admitted, so it is a logical corollary to use ultra-violet therapy in this disease.

The skin is a very important factor in the treatment of syphilis. Treatment by inunction is still the sheet-anchor of some of the soundest and most eminent of syphilologists.[1] Hesse also published a work in which he emphasises the importance of light in the treatment of syphilis. Rollier, who combines the light treatment with ordinary anti-syphilitic remedies, testifies that he has every reason to be satisfied with the results of the combination.

In syphilis the carbon arc body-bath is the most suitable form of applying the ultra-violet rays and should be taken in conjunction with anti-syphilitic treatment. In this connection it is not out of place to note, in *The Lancet*, July 5, 1924, the fact that Dr. Gino Murero, of the dermato-syphilitic clinic at Bologna, had published five cases of suppurative inguinal adenitis from venereal ulcers which yielded to treatment, and this tends to show that distinct beneficial effects can be obtained in intractable cases by exposure to solar rays. In all the five cases, improvement took place almost at once after four or five sittings; but the healing process increased about the ninth and tenth exposure with the disappearance of the œdema and of the bluish-red tint of the edges, and with the elimination of the necrotic patches, which are usually seen at the base of the ulcer and their replacement by healthy granulations, and consequent transformation and diminution of sanious discharge. Cure was usually complete after twenty-five sittings.

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[1] *Aachen Treatment of Syphilis*, by Dr. Reginald Hayes (Ballière, Tindall & Cox).

Tic Douloureux

Here, in addition to treatment with the air-cooled mercury vapour lamp, or local application of an arc, general treatment of the whole body will be of material aid, and if the theory be correct that this distressing and intractable complaint is due to a deficiency of calcium and an excess of magnesium, it will be seen that ultra-violet radiation is an important factor in bringing about a cure. Certain it is that in both tic douloureux and in obstinate cases of facial spasm patients do improve with ultra-violet therapy where everything else has failed.

That there are many other conditions and diseases in which benefit can be obtained from ultra-violet therapy is obvious from what has already been said. In general diseases such as anæmia and chlorosis, and local conditions such as old wounds and indolent ulcers, this has repeatedly been proved. But the rationale and technique of these and others which from time to time suggest themselves will be manifest from the consideration of what has been already written.

I feel that I have not done justice to the subject or sufficiently dilated upon the therapeutic value of ultra-violet therapy. Many items relative to the subject have been omitted, and many more deserve fuller mention; but if enough has been said to lead others to study the field of ultra-violet radiation and to afford relief to their patients by means of this very valuable therapeutic agent, I have not written in vain.

X-RAYS AS A COMPLEMENT TO ACTINOTHERAPY

CHAPTER VIII

X-RAYS AS A COMPLEMENT TO ACTINOTHERAPY

In the course of the Kelvin Lecture, which he delivered in 1921, Sir William Bragg observed that clear indications are to hand that, dependent upon further research, there is a strong possibility of equilibrium, or health in cell structure, being restored by means of X-ray treatment.

As radiography should not be considered as an isolated entity in diagnosis, but kept in corelation with other clinical methods of examination, so there seems to be reasonable ground for assuming, especially with regard to the various forms of light therapy, that X-rays can be used as a valuable adjuvant, or in working partnership with the rays of the spectrum not far removed from it.

Bayliss says, speaking generally, " the effect of the X-rays on cells is similar to that of ultraviolet light. Their lethal effect, however, continues for a long period." In recent confirmation of this, Sampson says: " In *lupus vulgaris*, often after the first few actinic ray treatments, a dermatitis dose of X-rays is of the greatest utility. Of course, this treatment alone will clear up some cases, and so will the actinic ray, but together they will do much better work. And again, some of the worst looking cases of general psoriasis that we have ever had, were sent in for treatment. Some of the more recent areas cleared up promptly under actinotherapy, but some of the older and more indurated regions were intractable until the ionising X-ray dose was added, when they cleared up also."

Before going farther, let us review in brief the nature of X-rays and their relation in the spectrum to the ultra-violet rays.

As a convenient definition of X-rays the following is submitted :

X-rays are the invisible rays emitted by an electrically excited Crookes' tube, which rays are capable of penetrating many substances opaque to light, and of producing actinic or fluorescent effects. In terms of wave length—

X-rays = 282 Å.
Ultra-violet = 360 Å to 4000 Å.
Visible spectrum = 4000 Å to 7000 Å.

It will be noted that there is a space between the X-rays and the ultra-violet rays, which was not for some time investigated ; but now that Millikan (R. 162) has been able to obtain a wave-length of 202 Å, and Holweck has produced X-rays of which the wave length is 500 Å, we may conclude that this space (which separated the ultra-violet from the X-rays) is now definitely bridged.

Even as they may be used together clinically, X-rays sometimes, not indiscriminately however, may be given when there is any dermatitis from ultra-violet radiation. When the ultra-violet radiation is given to increase skin tolerance, it should be allowed to die down before administering the X-rays. In lupus, where it is desired to produce an extreme dermatitis, the best results are obtained by superimposing the X-rays upon an ultra-violet dermatitis.

The importance of using X-rays as a complement to actinotherapy is very pronounced. At the same time, it must be observed that, largely as the effect of misinformed newspaper comment, there has been more demand for X-ray treatment, in any and every imaginable description of disease, than is either politic or justifiable. As a natural result, false hopes have too often been engendered, and disappointment has been inflicted. But as I pointed out recently,[1] I venture to foretell that the time will come, and very shortly now, when the field for ultra-violet radiation will transcend even the demand for X-ray therapy at the hour of its greatest popularity. The combined use of these two agents is one of the newer problems, which is likely to be well worth further examination and study.

In considering team work between X-ray and ultra-violet radiation, let us recall the way in which the former produces its therapeutic effect.

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[1] British Medical Association Annual Meeting, Bradford, July 1924.

(1) The endothelial lining of the blood vessels becomes œdematous, this œdema eventually occluding the artery and cutting off the nutrition of the growth, and resulting, if the treatment be pushed to that extent, in an obliterating endarteritis in the capillaries.

(2) X-rays appear to have especial action on new cells, on elementary embryologic tissue. Witness the way we are able to produce sterility, either temporary or permanent, by X-raying the ovarian or testicular region. Here the nucleus becomes cloudy, the nuclear membrane disappears and the débris is carried away by the process of phagocytosis, and replaced by connective tissue.

These and other changes that are brought about greatly depend upon the blood condition of the patient.

We have seen that ultra-violet rays are actually absorbed by the capillaries, and cause chemical changes in the composition of the blood, and I mention these changes, not as a logical conclusion, but rather as food for thought, and a possible explanation of the way in which may be brought about the good effects of the combined use of these two agents.

In the treatment of tuberculosis, Rollier has used the combination for the last ten years, and

Iselin studied the subject at his clinic at Basle, and was perhaps the first worker to secure good results from the combined use.

The problem of the successful use of X-rays in conjunction with actinotherapy involves, *inter alia*, two main questions. These are the measure of sensitivity of the pigmented skin to the X-rays, and the possibility that such simultaneous and combined application may be productive of cumulative effect. Researches show that the pigmented skin is not abnormally sensitive to such treatment. Should, however, the skin be exposed to the ultra-violet rays of the quartz lamp, the result is somewhat different. Thus, Rapp has reported having noticed lesions of the second and third degree, set up by a combination of X-rays and ultra-violet rays. If this were not intended it would appear that sufficient precaution had not been observed. Thus, if the ultra-violet rays are found to produce a violent reaction, the effect of the X-rays would naturally be to increase it. Such treatment should, accordingly, be reserved for cases where previous light treatment has already brought about a certain tolerance of the tissues.

Rollier, in summing up the situation, having stressed the fact that the therapeutic action of X-rays is largely governed by the differences in the sensitivity of the cell groups, gives it as his considered opinion in regard to the cumulative effect of the simultaneous application of light and of X-rays, that it would appear on the whole that no harmful consequence ensues. And if no harmful consequence ensue, and there be a possibility, even a probability, that beneficial effects will be obtained, then we are justified in pursuing our researches, and extending the benefits of the combined form of treatment.

In considering the therapeutic effects of these two agents, it is interesting to contrast their several actions on the skin. Either will produce a dermatitis ; but there are certain marked and easily recognised differences between X-ray and ultra-violet ray dermatitis. The former takes from eight to fifteen days to develop, and the latter usually occurs in a few hours from the beginning of the treatment. Again, X-ray dermatitis is apt to cause baldness, while ultra-violet dermatitis has a contrary result, and even stimulates the hair follicles. Indeed, the stronger the actinic ray reaction, the better its subsequent effect on the hair growth. Atrophic changes also may result from severe X-ray dermatitis. Yet ultra-violet dermatitis will, if there have been no heat-burn, not do much more than cause desquamation. The irritability of a given area to subsequently administered X-ray doses is increased by X-ray dermatitis, but it is decreased by the inflammatory reaction following a heavy actinic dosage. The cause of this increased tolerance of the skin to ultra-violet rays is not yet known definitely. We are, however, familiar with several contributory factors, which play their part in securing such a result. Among these are the loss of irritability arising from the inflammatory reaction, the tanning of the skin,

and the various blood chemistry changes which have an antidotal effect upon the cycle of tissue changes.

The conjoint employment of the X-ray and the ultra-violet ray in actinotherapy has been gradually evolved from careful and systematic researches into their respective local and general effects. The discovery of the comparative ease with which X-ray dermatitis would, if not too pronounced, yield to actinotherapy vigorously applied, was of the first importance and marked a big step. If, however, cicatricial tissues have already been formed, the case will not respond to actinotherapy treatment by itself. In these instances the scar must be softened or eliminated by some other means before recourse is had to the ultra-violet ray.

It has been seen that in X-rays we have an agent which will effect this.

It has been held by some authorities to be a clinical error to superimpose an actinic erythema on X-ray treatment. There is abundant clinical history, however, to prove that this has often been done without the occurrence of any additional dermatitis.

Again, during the late war, excellent results were obtained from the use of these two agents in combination in the treatment of painful scars. The more recent the formation of the cicatricial tissue, the more pronounced is the action. Apparently the X-ray disintegrates the fibrous tissue, and, as it often softens, the nerve fibres are as often relieved of their pressure. The ultra-violet rays have caused a hyperæmia with its beneficial effects. It is still a question as to whether post-operative prophylactic radiotherapy should not be advised as a corollary to all those operations for the liberation of nerves from scar tissue, and, if so, the addition of the ultra-violet radiation will, I think, prove a valuable coadjutor.

The foregoing pages lead to certain definite conclusions on the subject of the employment of X-rays as a complement to actinotherapy. Mankind has always been impinged upon by the actinic rays from the sun. Such solar actinism is necessary for the protection of people climatically exposed to the sun; and thus we have negroes and dark races of human beings.

Accordingly, even as with the addition of X-rays to ultra-violet therapy, our range of therapeutic effects is increased, so, too, we find that the ultra-violet radiation extends the previous limits of X-ray efficacy in the treatment of disease.

Up to the present, research has not gone far enough to make it possible to postulate any exact technique on this subject. Enough, however, has already been achieved to show clearly that the X-rays assist the therapeutic effects of the ultra-violet rays, and that each forms a valuable complement of the other.

As the human epidermis is Nature's protective agent against certain stimuli, the skin becomes a filter against such actinic effects as have to be excluded. The therapeutically valuable tanning

that results from "sunburn," is accomplished more rapidly and under more effective control, by the employment of scientific apparatus. The special function of such apparatus is to duplicate the therapeutically valuable actinic spectrum. The field of such research covers a vast, and as yet only partially explored, territory. Still, the essential feature of clinical research in this direction proves that X-ray and ultra-violet radiations are physiological complements, and may be used with good results in conjunction with each other.

A final word of warning.

A vast amount of nonsense is talked and written (and, unfortunately, believed) about the various rays in which experiments are being conducted. Some of them are being invested with all sorts of entirely imaginary attributes. Thus, one such is said to stop motor cars and aeroplanes. Another to photograph fairies; and yet another to enable its gifted operator to destroy fleets and armies at will. Some years ago, certain newspapers were full of what they called the "death-ray." This seemed an echo of the war. The inventor gave a demonstration before the army authorities. He certainly projected his so-called ray, or said he did, at a mouse, which immediately died. He was unable to repeat this, and as the table was found to contain an electrocuting apparatus which had to be set for each experiment, and the mouse would not be killed unless it were so set, regardless of any ray whatsoever, the fraud was discovered and the inventor spent some subsequent years enjoying forced labour in the trenches. It may be that the death-ray talked of in to-day's papers is similar. However, even as this is written, something else seems now to occupy the daily press, and it is as well.

There is enough material at present to occupy our minds with the correlation of X-rays with ultra-violet radiation, and with examining how far each may be used as a complement to the other for therapeutic purposes without concerning ourselves with mythical powers of imaginary rays.

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